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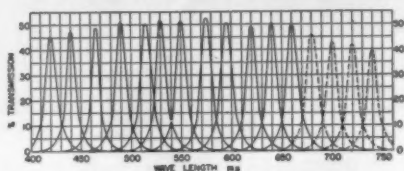
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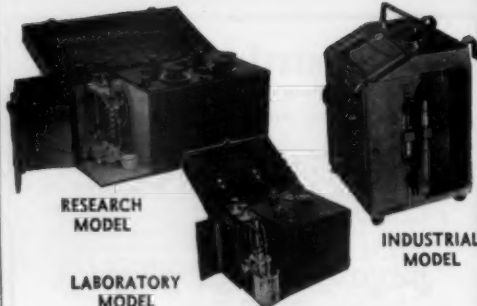
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For example, a scheme for short-term Anglo-French medical bursaries has been arranged between the Ciba Foundation and the Institut National d'Hygiène, and it is contemplated that this scheme shall be extended to other countries.

Informal symposia, or colloquia, strictly limited in membership, have been arranged between leading research workers from different countries, and these have been recorded in publications made available to their colleagues throughout the world. Of these conferences, there were nineteen between January 1950 and December 1952; twelve on endocrinological subjects, and the remainder on more general topics—e.g., toxemias of pregnancy, liver disease, the spinal cord, and the circulation.

Accommodation has been provided for important meetings of international committees concerned with various aspects of medical research. Small discussion groups, the proceedings of which remain unrecorded and unreported, also meet periodically; in these, distinguished overseas guests are invited to open debates on topics of their own choosing in the presence of small gatherings of those actively interested in similar research.

The library of the foundation has daily accessions, and the specialized section dealing in endocrinology already provides a service probably unique in Great Britain.

Words spoken by Sir Henry Dale on the occasion of the opening ceremony may be recalled: "It is more urgently necessary than ever before to widen and to multiply all legitimate channels of international understanding and co-operation in science." This aim is being realized by the Ciba Foundation in a variety of ways and on an ever-widening front.

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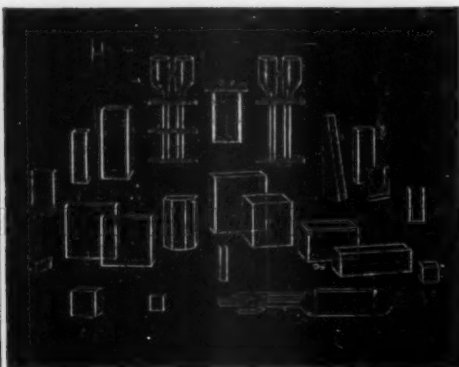
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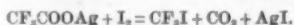
Organometallic and Organometalloidal Compounds Containing Fluoroalkyl Groups

H. J. Emeléus and R. N. Haszeldine

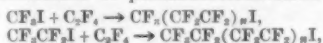
University Chemical Laboratory, Cambridge, England

THE SYNTHESIS in 1947 of trifluoriodomethane and pentafluoriodoethane may perhaps be considered as of special significance in the field of fluorocarbon chemistry, since it raised the possibility of obtaining organometallic and organometalloidal compounds containing fluoroalkyl groups. This field of investigation, which is as yet in its infancy, has already yielded a number of interesting results; and it is the purpose of this article to present the information so far gleaned and to draw attention to some outstanding differences between the well-known organometallic compounds and their fluorocarbon analogs.

Trifluoriodomethane was first prepared by the interaction of carbon tetraiodide and iodine pentafluoride, and was found to be a stable gas (bp, -22.5°) (1). The homolog, pentafluoriodoethane (bp, 13°) may be prepared similarly from tetraiodoethylene and iodine pentafluoride (1), or by the interaction of diiodotetrafluoroethane and iodine pentafluoride (2). Fortunately, however, a far more convenient method for preparing fluoroalkyl iodides was subsequently developed. This entails the thermal reaction between the silver salt of a fully fluorinated organic acid and iodine (3). Thus trifluoriodomethane may be prepared very simply from silver trifluoroacetate and iodine:



The higher members of the fluoroiodide series $\text{CF}_3(\text{CF}_2)_n\text{I}$ may be prepared by this route, or by the polymerization of tetrafluoroethylene with trifluoriodomethane or pentafluoriodoethane (4),



where $n = 1, 2, 3$, etc., and show properties very similar to the lower members of the series.

Trifluoriodomethane has an absorption spectrum very similar to that of methyl iodide and shows a broad maximum at ca. 2700 Å. The quantum yield for the photodecomposition is, however, low (< 0.01), unless an acceptor for either the trifluoromethyl radical or the iodine atom formed in the primary act be present. The fluoroalkyl radical produced photochemically is able to initiate the polymerization of unsaturated substances such as ethylene (4), tetrafluoroethylene (5), acetylene (6, 7), vinylic compounds (8), etc., in the vapor phase, and when in solution can abstract hydrogen or halogen atoms from neighboring solvent molecules (9). It appears that a similar homolytic fission of the trifluoriodomethane mole-

cule also occurs at a temperature of 200° , since, at this temperature, reactions are observed with parallel those initiated photochemically.

The first experiments designed to utilize the homolytic fission of trifluoriodomethane in the synthesis of organometallic compounds were performed with mercury (10), which, when heated or irradiated with the fluoroalkyl iodide in the absence of a solvent, yielded the white crystalline compound trifluoromethyl mercuric iodide, CF_3HgI . This sublimed readily at atmospheric pressure and was soluble in organic solvents; unlike its methyl analog, however, it was also soluble in water. There was a slow decomposition in aqueous solution, but reactions involving the mercury-iodine bond could be effected as follows:

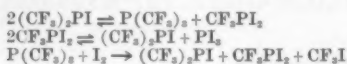


The trifluoromethyl mercuric iodide can be converted into bistrifluoromethyl mercury, $\text{Hg}(\text{CF}_3)_2$, by reaction with either copper or cadmium amalgams, reagents that will also convert trifluoriodomethane directly to the dimercurial (11). Several of the standard methods for obtaining dimethyl mercury from methyl mercuric iodide were found to be ineffective when applied to the fluorine-containing compound.

Bistrifluoromethyl mercury, unlike dimethyl mercury, which is a covalent liquid, is a white crystalline solid that is readily soluble in organic solvents and that sublimates at atmospheric pressure. It is also very soluble in water, in which solvent it is stable and shows a low conductivity which might be ascribed to complex ion formation—e.g., $\text{Hg}^{2+}[\text{Hg}(\text{CF}_3)_2]^-$. It is believed that in the formation of these mercurials the metal acts as an acceptor for the CF_3 radical, and the same is almost certainly true of the reactions between mercuric and other fluoroalkyl iodides, which has led to the synthesis of homologs of bistrifluoromethyl mercury (9).

Elementary phosphorus, arsenic, antimony, sulfur, and selenium undergo analogous thermal reactions with trifluoriodomethane. When, for example, the fluoroiodide is heated with white phosphorus at 250°C a mixture of the three compounds $\text{P}(\text{CF}_3)_3$, $\text{P}(\text{CF}_3)_2\text{I}$, and $\text{P}(\text{CF}_3)\text{I}_2$ is obtained in yields of about 60%, 30%, and 10%, respectively (12). The proportions may be varied by altering the reaction conditions, particularly the temperature and the relative amounts of the reactants.

The three trifluoromethyl-substituted phosphines are interconvertible. Thus, the iodo-compounds disproportionate on heating, and trisiodotrifluoromethyl phosphine will react with iodine:



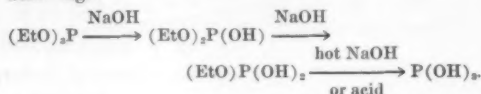
Trisiodotrifluoromethyl phosphine reacts with chlorine and forms the pentavalent derivative $\text{P}(\text{CF}_3)_3\text{Cl}_2$ (bp, 95°). With bromine or chlorine at higher temperatures, the reaction is similar to that with iodine referred to above, and partial replacement of fluoroalkyl groups by halogen atoms occurs—e.g., $(\text{CF}_3)_3\text{PCl}_2 \rightarrow (\text{CF}_3)_2\text{PCl}$, CF_3PCl_2 , PCl_3 , CF_3Cl .

Trisiodotrifluoromethyl phosphine is a colorless liquid (bp, 17.5°), which has a normal Trouton constant. Like trimethyl phosphine (bp, 38°), it burns in air, but, unlike this compound, does not give addition compounds with sulfur, carbon disulfide, or silver iodide (12). The influence of the strongly electronegative trifluoromethyl groups is clearly apparent. Triphenyl phosphine, which has a comparable molecular weight, is a solid (mp, 79° , bp $> 360^\circ$), so that the influence of fluorine on volatility is again illustrated. Compounds such as $\text{P}(\text{CCl}_3)_3$ have not been prepared, and the known monochloro derivative $\text{P}(\text{CH}_2\text{Cl})_3$ (bp, $100^\circ/7\text{ mm}$) is unstable on distillation at atmospheric pressure.

Iodobistrifluoromethylphosphine (bp, 73°) fumes in air but is noninflammable; the corresponding methyl phosphine has not been prepared. The diiodo compound, CF_3PI_2 , is a yellow oil (bp, $69^\circ/29\text{ mm}$) which also has no hydrocarbon analog. All three trifluoromethyl-substituted phosphines are substantially insoluble in water, and the tris-substituted compound reacts with it only at temperatures $> 100^\circ$ to give a slow hydrolysis with liberation of fluoroform. Both the mono- and the diiodo-compounds are hydrolyzed slowly by water at room temperature. The former loses one molecular proportion of fluoroform, and both reactions yield a crystalline dibasic acid formulated as $\text{P}(\text{CF}_3)(\text{OH})_2 \cdot \text{H}_2\text{O}$, although the characterization is not yet complete. This acid, which has strong reducing properties, is readily oxidized by aqueous hydrogen peroxide to a second dibasic acid $\text{P}(\text{CF}_3)\text{O}(\text{OH})_2$.

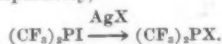
These acids are stable to dilute alkali, although the fluoroalkyl-substituted phosphines themselves are quantitatively decomposed with elimination of all the fluorine as fluoroform. These hydrolytic reactions constitute one of the most interesting features of this group of compounds. The chloro derivative $\text{P}(\text{CH}_2\text{Cl})_3$ is reported to be stable to alkali, but little is known about other trialkyl or triaryl phosphines in this connection. Rupture of the P—C bond seems, however, to be rare. The ease of hydrolysis of the trifluoromethyl compounds is associated with the negativity of the CF_3 groups, and a parallel can be traced with phosphorus compounds that contain alkoxy or aryloxy groups attached to the phosphorus atom. Thus, ter-

ary phosphites are readily hydrolyzed by alkali to the more stable secondary phosphites which, on further hydrolysis, yield primary phosphites. Hot alkali or acid treatment is then necessary to give phosphorous acid—e.g.:



Many tertiary phosphites can, indeed, be hydrolyzed by water alone, and in this respect the P—O bond is less stable than the P—C bond in the P— CF_3 derivatives. Of the aryl derivatives, $\text{P}(\text{OC}_6\text{H}_5)_3$ is also slowly decomposed by water to phenol and phosphorous acid, and, similarly, $(\text{C}_6\text{H}_5)_2\text{P}(\text{OC}_6\text{H}_5)$ with sodium hydroxide yields $(\text{C}_6\text{H}_5)_2\text{P}(\text{OH})$ and phenol (as sodium salts).

The iodine atom in iodobistrifluoromethylphosphine is reactive and can be replaced by other groups. Silver cyanide and chloride, for example, react very readily and give quantitative yields of the cyano and chloro derivatives, respectively,

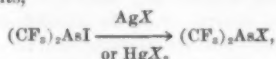


With mercury the monoiodo compound gives a quantitative yield of the trifluoromethyl-substituted diphosphine, $(\text{CF}_3)_2\text{P—P}(\text{CF}_3)_2$ (bp, 84°), which has no known methyl analog. A similar reaction has been observed with bromine. The monoiodo compound has also been shown to be reduced by hydrogen in the presence of Raney nickel to the substituted phosphine, $(\text{CF}_3)_2\text{PH}$ (bp, 1°), the chemistry of which is under investigation (12).

The reaction of arsenic with trifluoriodomethane (13) is very similar to that of phosphorus. At 200° – 240° the product from excess of solid arsenic contains ca. 60% $(\text{CF}_3)_3\text{As}$ (bp, 33.3°), 30% $(\text{CF}_3)_2\text{AsI}$ (bp, 92°), and 10% $(\text{CF}_3)\text{AsI}_2$ (bp, 154°). These compounds can be interconverted by heating the iodo-compounds or by reaction with iodine, exactly as in the case of their phosphorus analogs. They do not ignite in air and are insoluble in, and stable with respect to, water at room temperature. The trisiodotrifluoromethyl arsenic shows no reaction with 3 N hydrochloric acid at room temperature but, at 200° , yields fluoroform and arsenious acid. As was found for the phosphorus compounds, the trifluoromethyl derivatives of arsenic are very susceptible to aqueous alkali, and use has again been made of this for analysis; cold 10% sodium hydroxide converts $(\text{CF}_3)_3\text{As}$, $(\text{CF}_3)_2\text{AsI}$, and $(\text{CF}_3)\text{AsI}_2$ quantitatively into fluoroform and sodium arsenite. The compound $\text{As}(\text{OCH}_2\text{CH}_2\text{Cl})_3$, which bears some analogy to trisiodotrifluoromethyl arsenic by virtue of the negative oxygen atom attached to the arsenic, shows a similar hydrolysis with alkali and even with water: the products are $\text{CH}_2\text{OH} \cdot \text{CH}_2\text{Cl}$ and As_2O_3 . Similarly, $\text{PhAs}(\text{OCH}_2$

$\text{CH}_2\text{Cl})_2$ yields PhAsO and $\text{CH}_2\text{OHCH}_2\text{Cl}$, and it will be noted that it is the more negative group that is lost. Trimethyl arsine is stable to hydrolysis by alkali, and when phenyl replaces the methyl groups, as in Ph_3As , the compound is also stable to hydrolysis by cold alkali; in this particular instance, hot alkali yields Ph_3AsO .

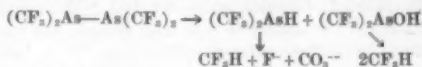
Like the iodine atom in iodobistrifluoromethylphosphine, that in $(\text{CF}_3)_2\text{AsI}$ is reactive and may be replaced by other groups by reaction with silver or mercury salts,



where $\text{X} = \text{F}, \text{Cl}, \text{Br}, \text{CN}, \text{CNO}, \text{SCN}$.

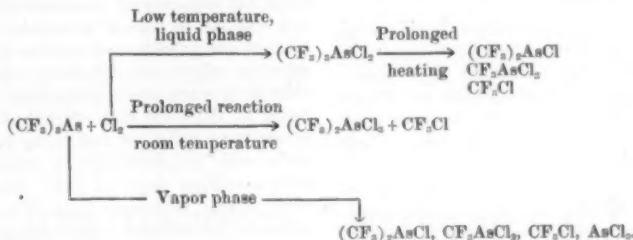
Attempts have been made to prepare an acid by the hydrolysis of $(\text{CF}_3)_2\text{AsI}$, but, as mentioned earlier, this compound does not hydrolyze with water at room temperature, and alkaline reagents yield only fluoroform. Aqueous silver oxide gives a compound that may be the silver salt, $(\text{CF}_3)_2\text{AsOAg}$, whereas moist mercuric oxide gives an immediate precipitate of mercuric iodide and white needle crystals, moderately soluble in water, of a compound believed to be $[(\text{CF}_3)_2\text{AsO}]_2\text{Hg}$. The monoiodide is oxidized by aqueous hydrogen peroxide to a dibasic acid, $(\text{CF}_3)_2\text{AsO}(\text{OH})$, a white crystalline solid that is freely soluble in water and may also be recrystallized from chloroform. This acid is almost completely dissociated in aqueous solution, whereas the dissociation

phosphorus analog $\text{P}_2(\text{CF}_3)_4$. The hydrolysis of the perfluoro cacodyl oxide, on the other hand, is normal in the sense that all the fluorine is evolved as fluoroform. Although the complete mechanism of the hydrolysis of tetrakis(trifluoromethyl)diarsine has not yet been fully established, it is likely that hydrolysis involves attack of the $\text{As}-\text{As}$ bond, as shown below:



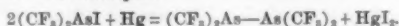
Both of the substituted arsines, $(\text{CF}_3)_2\text{AsH}$ (bp, 19°) and $(\text{CF}_3)_2\text{AsH}_2$ (bp, -14°), have been prepared in good yield by reduction of the corresponding iodides with lithium aluminum hydride and, in their reaction with alkali, provide evidence in support of the above mechanism, since fluoride and carbonate, as well as fluoroform, are liberated (13).

The interaction of trifluoromethyl arsine with the halogens has been investigated, and it has been found that with chlorine there is a slightly exothermic reaction at room temperature to give $(\text{CF}_3)_3\text{AsCl}_2$ (bp, 98.5°), only a trace of CF_3Cl being formed. The dichloro-compound may be distilled rapidly at atmospheric pressure without decomposition, but, on heating in a sealed vessel at 125° for several hours, chlorination occurs to give CF_3Cl , CF_3AsCl_2 , and $(\text{CF}_3)_2\text{AsCl}$. Prolonged reaction of chlorine and trifluoromethyl arsine at room temperature gives $(\text{CF}_3)_2\text{AsCl}_2$ (bp, 94°), together with CF_3Cl . It will

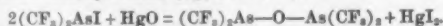


constant of the corresponding methyl acid is of the order of magnitude of 10^{-6} to 10^{-7} .

The bistrifluoromethyl halogeno arsines readily attack mercury, and, if this reaction is allowed to proceed to completion, then a simple dimerization to perfluoro cacodyl—i.e., tetrakis trifluoromethyl diarsine—occurs. For example:



The boiling point of the perfluoro cacodyl (106° – 107°) is ca. 64° lower than that of the methyl cacodyl. A similar reaction with mercuric oxide yields perfluoro cacodyl oxide (bp, 95° – 97°):



The hydrolysis of the perfluoro cacodyl by aqueous alkali is interesting in that approximately 75% of the fluorine appears as fluoroform and the remainder as fluoride and carbonate ions. The same is true of the

be noted that replacement of a CF_3 group by chlorine in the pentavalent arsenic compound changes the boiling point only slightly.

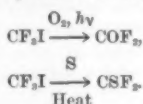
Arsenic tribromide formation can be observed when trifluoromethylarsine and bromine are mixed even at temperatures below 0° , and a stable pentavalent compound $(\text{CF}_3)_3\text{AsBr}_2$ cannot be isolated. The products of reaction at room temperature are $(\text{CF}_3)_2\text{AsBr}$ (bp, 60°), CF_3AsBr_2 (bp, 119°), CF_3Br , and AsBr_3 . Trifluoromethylarsine reacts very slowly with iodine at room temperature, if at all, and appreciable reaction occurs only at 100° to give $(\text{CF}_3)_2\text{AsI}$, CF_3AsI_2 , CF_3I , and AsI_3 .

Irradiation with ultraviolet light of a mixture of trifluoromethyl arsine and methyl iodide, which shows no tendency to form a quaternary compound at moderate temperatures, leads to an exchange between methyl and trifluoromethyl radicals. As a

result, trifluoroiodomethane and compounds of the type $(\text{CF}_3)_n(\text{CH}_3)_{3-n}\text{As}$ are formed. The compound $(\text{CF}_3)_2(\text{CH}_3)\text{As}$ (bp, 52°) is independently synthesized from methyl magnesium iodide and $(\text{CF}_3)_2\text{AsI}$, and the identity of products firmly establishes this novel exchange reaction, which is being subjected to detailed examination.

The reaction between antimony and trifluoroiodomethane (14) is similar to that with arsenic, the main product, trifluoromethyl stibine (bp, 72°), being accompanied by $(\text{CF}_3)_2\text{SbI}$ and $(\text{CF}_3)_3\text{SbI}_2$. The monoiodide, however, is decidedly less stable than its arsenic analog and disproportionates at room temperature, with separation of red crystals of antimony triiodide. The monoiodide reacts readily with mercury to give the distibine $(\text{CF}_3)_2\text{SbSb}(\text{CF}_3)_2$, and with aqueous hydrogen peroxide to give $(\text{CF}_3)_2\text{SbOOH}$.

The interaction of sulfur and trifluoroiodomethane occurs smoothly at 200° – 260° in sealed glass tubes or in an autoclave to give a high yield of a compound $\text{C}_2\text{S}_2\text{F}_6$. The main by-product is thiocarbonyl fluoride, CSF_2 , formed in negligible amount under optimum conditions, but in higher yield at more elevated temperatures. Thiocarbonyl fluoride is the analog of the carbonyl fluoride obtained by irradiation of trifluoroiodomethane in the presence of oxygen:



The main product, $\text{C}_2\text{S}_2\text{F}_6$, is a dense liquid, which is stable to glass and to mercury, with a boiling point of 35° and a normal Trouton constant. It is decomposed rapidly by aqueous alkali to give not fluorocarbon, as found for the majority of the compounds mentioned earlier, but completely fluoride, sulfide, polysulfides, and carbonate.

The structure of this compound is proved by two of its reactions. With chlorine at 330° , approximately 90% of the fluorine may be recovered as CF_3Cl , showing that two CF_3 groups are present in the molecule. This conclusion is supported by the reaction with mercury in ultraviolet light, when a very high yield of the crystalline compound $\text{Hg}(\text{SCF}_3)_2$ is formed. The structural formula may thus be written as $\text{CF}_3-\text{S}-\text{S}-\text{CF}_3$. The infrared spectrum is also consistent with this structure (15). In the initial reaction two other products, $(\text{CF}_3)_2\text{S}_2$ (bp, 86.5°) and $(\text{CF}_3)_2\text{S}_3$ (bp, 135°), are formed and have been isolated (16). It is not known whether these contain a straight or a branched sulfur chain, although by analogy with other polysulfides the former is more likely.

Very few polyhalogenated alkyl sulfides have so far been prepared, and those that are known are clearly less stable than the fluoro compounds. Thus, bistrichloromethyl sulfide, which has been prepared, for example, by the action of chlorine on dimethyl sulfide, is readily decomposed into carbon tetrachloride and thio-

carbonyl chloride. Bistrichloromethyl disulfide, which is obtained by the action of zinc dust on perchloromethanethiol:



decomposes on distillation at atmospheric pressure:



On irradiation with ultraviolet light, bistrifluoromethyl disulfide liberates free sulfur and yields quantitatively the monosulfide $(\text{CF}_3)_2\text{S}$ (bp, -22°). The last compound is extremely inert to aqueous alkali, thus differing sharply from the disulfide and resembling the perfluoro-ethers, such as $(\text{CF}_3)_2\text{O}$ (17), which show a general chemical inertness comparable with that of the fluorocarbons.

The interaction of trifluoroiodomethane with selenium (14) differs from that with sulfur in that both the monoselenide, $(\text{CF}_3)_2\text{Se}$ (bp, -1°), and the diselenide, $(\text{CF}_3)_2\text{Se}_2$ (bp, 70°), are formed under optimum conditions in an approximate ratio of 2:1. At temperatures above 290° the yield of diselenide diminishes rapidly, because of the reversal of the primary reaction, and, at 300° , bistrifluoromethyl diselenide and iodine give a quantitative yield of trifluoroiodomethane and selenium.

Bistrifluoromethyl selenide is stable to acids and alkalis at room temperature but gives almost a quantitative yield of fluorocarbon when treated with concentrated alcoholic potash at 100° . There is little reaction with chlorine at temperatures up to 100° in the dark, but exposure of a mixture of the monoselenide and chlorine to filtered ultraviolet light brings about a rapid and quantitative conversion to trifluoromethyl selenium trichloride, CF_3SeCl_3 and CF_3Cl . The trichloride is a white crystalline solid with a sublimation point of $180^\circ/760$ mm which hydrolyzes rapidly on exposure to moist air and forms trifluoromethyl seleninic acid, $\text{CF}_3\text{SeO}(\text{OH})$, a white crystalline solid with a melting point of 118° , shown by titration to be a strong monobasic acid. The marked inductive effect of the trifluoromethyl groups is shown by the failure of bistrifluoromethyl selenide to give the reactions with reagents such as nitric acid, methyl iodide, and heavy metal salts, which are characteristic of the methyl analog. This difference is indeed common to the methyl and trifluoromethyl derivatives of all the elements so far studied.

Bistrifluoromethyl diselenide is stable to water and to dilute acids but is readily hydrolyzed to fluoride, carbonate, and selenide by aqueous potassium hydroxide at room temperature. Reaction with chlorine occurs at temperatures below -10° and yields a mixture of CF_3SeCl_3 and the monochloride, CF_3SeCl , which is a red liquid boiling at 32° , converted by an excess of chlorine to the trichloride CF_3SeCl_3 . The chlorine atom in the monochloride may readily be replaced by other groups by reaction with silver or mercury salts. Its reaction with mercury gives bis(trifluoromethylseleno)mercury, $\text{Hg}(\text{SeCF}_3)_2$, a white crystalline solid of low melting point (ca. 40°), which

is soluble in water and may readily be sublimed, as well as the compound CF_3SeHgCl . The dimercurial is the analog of the sulfur compound $\text{Hg}(\text{SCF}_3)_2$, which has already been mentioned, and, indeed, may be produced in a similar way from the diselenide, $(\text{CF}_3)_2\text{Se}_2$, by reaction with mercury in ultraviolet light. The bromination of the diselenide at 150° gives only selenium tetrabromide and bromotrifluoromethane, but at lower temperatures CF_3SeBr_3 and CF_3SeBr can be isolated.

Although indications have already been obtained that the preparation of other fluorinated organometallic compounds of other elements (e.g., Al, Ga) will be possible by the general method described above, it is questionable if this approach will prove satisfactory in all cases. Indeed, it is already known that the more reactive electropositive metals react readily with free fluoroalkyl radicals and are converted to fluorides. There is thus a need for other approaches to this problem. One, which is of considerable interest from the point of view of reaction mechanism, is the use of radical exchange reactions, as illustrated by the work already mentioned on the preparation of arsenicals containing both alkyl and fluoroalkyl radicals. A more general solution to the problem is now available, however, with the successful preparation of perfluoroalkyl Grignard reagents (18). It has already been shown that these compounds, although appreciably more difficult to manipulate than their hydrocarbon analogs, can under suitable conditions react with organic functional groups such as $-\text{CHO}$, $>\text{C}=\text{O}$, $-\text{COOR}$, $-\text{CN}$, $-\text{COCl}$. Furthermore, reaction of trifluoromethyl magnesium iodide with silicon tetrachloride yields, with related compounds, bistrifluoromethyl silicon dichloride $(\text{CF}_3)_2\text{SiCl}_2$ (19). This opens up interesting possibilities in the field of perfluorosilicones.

The above account does no more than outline the present state of knowledge. The perfluoroalkyl derivatives of the elements other than carbon constitute a vast new branch of chemistry, the study of which is only just beginning. It is already apparent, however, that such a study will throw considerable light on the current theories of chemical reactivity, as well as providing compounds of value in both the academic and industrial worlds.

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The International Astronomical Union

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THE International Astronomical Union held its eighth general assembly in Rome, September 3-13. Founded in 1919 by the International Research Council (now the International Council of Scientific Unions), it is the oldest among the scientific unions of the world. Because the earth is a sphere and at any one place on its surface only half the sky is observable, astronomers have since ancient times depended more than other research workers upon international cooperation.

The Astronomical Union is unusual in another re-

¹ The views expressed in this article are my own. I present them as an American astronomer, and not as the president of the International Astronomical Union.

spect—it is the only union in which the USSR takes an official part, with 32 other participating countries. This is a source of professional gratification to the astronomers of the United States; it is also the origin of a large number of thorny problems. To deal with the latter, as well as with the more ordinary problems that confront all unions, the Department of State, working with the National Research Council, appointed a delegation to the Rome meeting, which consisted of J. J. Nassau, I. S. Bowen, G. M. Clemence, D. Brouwer, and F. L. Whipple as members. G. P. Kuiper was appointed as an alternate. I was named as chairman of the delegation.

The United States delegation held conferences in

Rome and kept in close touch with all developments. As the American vice president of the union, I worked with the executive committee, which consisted of the president, B. Lindblad (Sweden), the general secretary, B. Strömgren (Denmark and United States), V. A. Ambarzumian (Soviet Union), and three other vice presidents.

The Soviet Union's delegation of 12 members took an active part in all discussions and contributed to the scientific symposia on various subjects. They had brought with them a large number of books and periodicals on astronomy, which they distributed generously among the participants of the meeting. Dr. Ambarzumian reiterated on several occasions that international cooperation in astronomy is of the utmost importance, and that the Soviet astronomers will continue their efforts to preserve it.

Despite these friendly overtures, however, differences resulting from the enormous gap in ideology that now separates the East from the West appeared at once to intrude themselves into the realm of science from the administrative and from the subject matter side. As to administrative differences, I may cite the matters of selecting a place for the next meeting of the assembly and of electing the president of the union.

Without prior notice to the executive committee, the Soviet delegate, Dr. Ambarzumian, presented before the Rome general session an address in which he invited the union to assemble in the Soviet Union at its next meeting in 1955. The Soviets had previously (1948) issued an invitation to meet in Leningrad for the assembly in 1951. Although the executive committee had at first accepted this invitation, it reversed its decision in 1950. At that time the Soviet astronomers reproached President Lindblad and General Secretary Strömgren, apparently for the part the Soviets believed these officers took in reaching the decision. The next year (1951) the executive committee met in Paris. At this meeting the Soviets renewed their invitation to hold an assembly in the Soviet Union. The executive committee, however, again declined and agreed to meet instead in Rome for its 1952 conference. Thus, Dr. Ambarzumian's offer at Rome was the third invitation to astronomers to meet in the USSR.

The United States delegation unanimously agreed that it could not vote in favor of the Soviet invitation, and the executive committee decided against acceptance. Dr. Ambarzumian then proposed that he withdraw his invitation, and that an invitation from Poland extended by E. Rybka be accepted. The members of the executive committee felt that there was even less reason from the standpoint of astronomical interest and scientific productivity to meet in Poland. Dr. Ambarzumian would not yield his position and repeated over and over that "the Soviet delegation insists that the Polish invitation be accepted." He declared that any other decision would be "political" and would be detrimental to science and the cause of international cooperation. This uncompromising stand of

the Soviet delegation was a new experience in the affairs of the Astronomical Union, and it resulted in visibly uncomfortable and embarrassed feelings among the national delegations.

The United States delegation had expressed the wish that I undertake to explain frankly why we believe that a meeting in the Soviet Union under the existing conditions is undesirable. I was given the opportunity to do so inside and outside the sessions of the executive committee, and I stated that, contrary to certain press reports, the U. S. government had in no way exercised pressure upon its astronomers in the matter of the earlier cancellation of the Leningrad meeting; that it had issued no instructions to the American delegation in regard to the latest Soviet invitation and would undoubtedly accept the opinion of that delegation, whatever it might be; and that the individual opinions of the American astronomers, being unhampered by government policy, might be assumed to range from one extreme to the other. I pointed out that most astronomers undoubtedly felt as I did: that it would be inconsistent with our feeling of self-respect to become the guests of an organization whose members keep up a barrage of insults of the kind that had appeared in a recent book by Professor Parenago, who had applied to us the word *mrakobesny* (literally, "obscurantist devils" or "devil worshippers"); that we hoped that such indications of hatred against Western scientists might be temporary in character; and that the time would come when we could feel assured that a meeting in the Soviet Union would be a success. I added that, because of a number of analogous considerations, the United States delegation had withdrawn its own invitation in 1948 to the Astronomical Union to meet in this country and had not renewed it. In sum, I stated that, rather than risk a limited or inharmonious assembly, we had decided to wait until political tensions had disappeared.

Since the executive committee could not reach unanimity on the question of the meeting place for the next assembly, the matter was left to a vote of the general session. Out of seven original invitations, five were quickly eliminated. The USSR withdrew in favor of Poland; Great Britain (proposed by Harold Spencer-Jones) withdrew, largely in view of Dr. Ambarzumian's objection; Belgium had made its invitation subject to its being agreeable to all other nations (the Soviet Union objected and thus eliminated it); Argentina (proposed by Professor Gratton) was considered not suitable at the present time; an invitation from Norway (tendered by Professor Rosseland) was too tentative to permit immediate action. This left Poland and Eire (the latter having announced its invitation through Professor Brück, of Dublin). The vote was 21 for Eire, five for Poland; two abstained.

Another difficult administrative problem arose in connection with the election of new officers. President Lindblad proposed me as a candidate for president of the union. I replied that the American astronomers had decided to nominate J. H. Oort, of Leiden, Hol-

land, who had previously indicated that he would not be available, but who might be persuaded to accept the election as a "draft." The Soviet delegate, while expressing his highest personal regard for the candidates, registered his objection to the election of either. He then nominated A. Danjon, of France. The executive committee (whose meeting I did not attend) voted on the three candidates, and then the matter was referred to the general assembly. The latter body chose me for president by acclamation.

My acceptance speech was intended in part to relieve the tension brought about by the vote on the place for the 1955 meeting. I spoke, in part, as follows:

I am deeply touched by your action, and I thank you. I am also intensely embarrassed, and at this particular moment I should much rather be exploring the catacombs of Rome than standing here before you exposed in full glare to your friendly, yet searching gaze.

I believe that I do not possess some of the qualifications that have made other presidents great. But in one respect, and in one respect only, I feel qualified to carry out the task that you have assigned to me. Because of my family's background, and also because of the experiences of my own life, I have become a confirmed internationalist and believer in the necessity for international cooperation. I feel most at home in an organization such as the International Astronomical Union.

During the postwar years our Union has made great strides forward, under the wise direction of Sir Harold Spencer-Jones and Professor Lindblad. There have been many important developments since the Zurich meeting. Of most of them our general membership knows little, because much of the work of this Union is done in commissions. But three particularly great events stand out in our minds:

First, there was the admission of Germany. This action represented the healing of a wound that had threatened the very life of the Union from its beginning.

The second development was the rise of the symposia. Never before have we had so many excellent symposia. And with this development has come the realization that purely scientific matters should have precedence over matters of an organizational character.

The third, and perhaps the most significant, development is the tremendous impact upon this meeting of the scientific contributions from the Soviet Union. The whole-hearted cooperation of the Soviet astronomers, their generosity in the distribution of books, and their understanding in the matter of preparing in advance printed translations of their symposium papers, are a source of hope for us and for the world.

These and many other advances have been the result of President Lindblad's work for the Union. I propose a standing vote of thanks to Bertil Lindblad.

There had been some concern about electing as president an American scientist, and, as a matter of fact, the election of Dr. Oort would have been in many respects an excellent solution. Nevertheless, I agree with Dr. Strömgren, Dr. Oort, and Dr. Lindblad that the choice of the executive officers of the union should not be determined primarily by political considerations. The office of president involves a considerable amount of work, most of which is of a purely scientific nature.

It should be assigned to a person well versed in the real business of the union.

There have been two previous American presidents: W. W. Campbell, director of the Lick Observatory and later president of the University of California (1922-25), and F. Schlesinger, director of the Yale University Observatory (1935-38). Two presidents were French, three were British, one was Dutch, and one Swedish.

Returning to the question of our relations with the Soviets, it is inevitable that the present tense political situation be reflected in them. Soviet scientists are probably guided by detailed instructions from their government, and they find it difficult to understand that American scientists are not bound by similar instructions. Informally I had opportunities to explain that we do not have a "party line" that rigidly determines our action, that among the American astronomers many different views are permitted to be represented, and that our course is charted in accordance with the wishes of the majority.

On the purely scientific side there were important symposia on stellar evolution, astronomical instruments, a catalogue of the positions of faint stars, and on the spectra of variable stars. The most important single advance was contained in a lecture by J. H. Oort, on the structure of the galaxy as inferred from observations with a new radio telescope. This strange instrument, resembling a large wartime radar antenna, records hydrogen waves from interstellar space having a wavelength of 21 centimeters. These waves pass unobstructed through the vast clouds of cosmic dust which restrict our vision in ordinary optical light. Dr. Oort presented an outline of our galaxy as it might appear from a distant point some millions of light years away. The result is a pattern of spiral arms like a huge fiery pinwheel, rotating at an immense speed and with its arms trailing behind.

Most astronomical research work is unclassified—and this is one reason why free international meetings of astronomers are relatively little affected by security regulations. Individual astronomers may be diverting their attention temporarily to practical research in the field of physics, and this may have resulted in the absence from Rome of persons who normally would have been present. It is impossible even to venture a guess as to what extent this may have reduced the attendance from the various countries. With about 500 astronomers officially registered, the meeting was the largest ever held under the auspices of the Astronomical Union.

In the scientific symposia, especially the one on stellar evolution, it became apparent that there had appeared between the Western astronomers and the Soviets a rift that had no direct bearing upon the political situation. There has always been a serious language barrier between us and the Soviets. Previously, most Soviet scientists knew the English, French, and German languages, and they had no difficulty in reading and using our publications. It is my impres-

sion that, although they still greatly surpass us in linguistic proficiency, there is an increasing tendency to disregard as unimportant our discoveries and ideas.

On our side the problem is even more acute. Since 1947 the Soviet scientific publications have been entirely in the Russian language. There are no longer even abstracts in English or French. No matter how understandable may be the Soviet demand for "equal rights" in the matter of languages, there is no doubt that most Western scientists fail to make use of Soviet scientific work. For many years they have been pursuing a course of scientific activity that has remained unknown, or little known, in America, and our own advances no longer benefit them as they should. At the stellar evolution symposium various misunderstandings could be attributed to this lack of knowledge and of interest on the part of each group in what the other was doing. This lack of knowledge is sure to generate contempt.²

I fear that there may already be signs of disregard on our part for the work of the Soviet astronomers. Such an attitude would be a great mistake and would

² There is plenty of contempt for our work in the Soviet publications (see my article in *Science*, 116, 206 [1952]), but at the Rome meeting it was either very cleverly concealed or, more likely, it was never genuinely present.

render a disservice to the United States. The fact that the Soviets have been unaware of some recent discoveries at Mount Palomar or at Harvard does not render their work useless or prove that they are not capable research workers.

My own careful appraisal, based upon my knowledge of the Russian language and upon thousands of hours spent in studying their publications, leads me to conclude that:

- a) They have more research workers in astronomy than we have;
- b) Their training is, on the whole, better than ours;
- c) They possess, on the average, less initiative than do our scientists;
- d) Their natural abilities are about the same as ours, but they tend to do better in theoretical studies than in observational and experimental work;
- e) The present output of research in the Soviet Union is enormous in amount, but its quality is inferior to ours;
- f) They do not now possess astronomical telescopes of the power of our 200-inch, 120-inch, 100-inch, and even our 82-inch and 69-inch telescopes, but they are making rapid strides in the construction of new and, in some respects, novel auxiliary equipment; and
- g) The acceleration in all fields of astronomical endeavor—training, research, publication, and public instruction—is livelier than in the Western world.

News and Notes

American Anthropological Association

THE 51st annual meeting of the American Anthropological Association was held Dec. 28-30, at the University Museum in Philadelphia. The total number of registrants was 450, the largest in the history of the association.

The chairman of the Program Committee, G. R. Willey, had arranged symposia on Human Nature; American Ethnology—An Inventory; Anthropologists and Technical Assistance (cosponsored by the Society for Applied Anthropology); Methods of Determining Significant Degrees of Relationship (cosponsored by the American Association of Physical Anthropologists); Recent Progress and the Present Status of American Archaeology (cosponsored by the Society for American Archaeology); and Old World Archaeology—The Integration of Relative Chronologies (cosponsored by the Archaeological Institute of America). In addition, there were programs of miscellaneous papers devoted to such topics as New World archaeology and culture history, applied anthropology, Asiatic ethnology, African and Haitian ethnology, the ethnology of Oceania, social anthropology, American Indian acculturation, and American ethnology and culture history. The total number of papers listed for presentation was 91, of which a few

were cancelled because of the inability of the speakers to be present.

A special luncheon was held by the American Ethnological Society to discuss informally publication problems in ethnology. About 60 persons were present, with G. P. Murdock presiding.

The Executive Board held meetings on Dec. 27, 28, and 30, the chief matters of discussion being the annual budget and problems of publication. Sol Tax, incoming editor of the publications of the association, was invited to present his program of action. He vigorously supported an aggressive publication policy designed to expand the *American Anthropologist*, the *Memoirs*, and the *Bulletin*. His goal is to increase the annual number of issues of the *American Anthropologist* from four to six, and to multiply the annual numbers of the *Memoirs* series. Dr. Tax presented proposals for financing this expanded program and was able to report heartening progress. The Executive Board, as part of its business, also voted to accept 54 persons as Fellows.

The annual business meeting of the Council, presided over by Wendell C. Bennett, president of the association, was attended by 143 Fellows. At this time the election of the following officers was announced: J. O. Brew, president-elect for 1953, and Harry Hoijer and Lauriston Sharp, members of the Execu-

tive Board for 1953-55. The new president is Fred Eggan, elected in 1951 under a new plan designed to give experience and continuity to incoming presidents by having them serve a year on the Executive Board as presidents-elect. The association noted with regret the death of three Fellows: Peter H. Buck, D. S. Davidson, and Karl Schmitt, Jr. It was announced that Julian H. Steward had been awarded the Viking medal and award in cultural anthropology.

An innovation of experimental character was the substitution by the association of a cocktail party for the traditional annual banquet. Held at the Penn-Sheraton Hotel, it was an unqualified success.

Local arrangements were under the supervision of F. G. Rainey, director of the University Museum of the University of Pennsylvania. He was ably assisted by several individuals, of whom special mention should be made of Alfred Kidder II, for so splendidly handling the mechanics of registration and the arrangement of lecture rooms and other accommodations. The museum gave a cocktail party for all registrants at the convention. This, supplemented by other arrangements, provided members with an unparalleled opportunity to engage in informal discussions. All evenings were left free of scheduled events.

The 1953 meeting will be held in December at Tucson, Ariz., with Edward H. Spicer in charge of the program, and Emil W. Haury in charge of local arrangements. The 1954 meeting will be held at Ann Arbor, Mich.

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Scientists in the News

Glady's M. Keener, executive editor of *SCIENCE* and *THE SCIENTIFIC MONTHLY*, and Howard A. Meyerhoff, administrative secretary of the *AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE* and chairman of the Editorial Board, will voluntarily discontinue their duties with the Association on March 31, and will subsequently submit their resignations. Their reasons for taking this step, announced to the directors a month ago, are administrative. Although the Publications Committee has formulated publication policy and is responsible for the directives under which the journals are operated, the editors have been repeatedly and severely criticized by the president, E. U. Condon, both for the content of *SCIENCE* and for its rigorous editorial standards. Critical of AAAS journals and meetings, the president-elect, Warren Weaver, took vigorous exception to the editorial "Boston 1953" (*SCIENCE*, 117, ad. p. 3 [Feb. 20, 1953]), in which the administrative secretary reaffirmed the soundness of current AAAS policies and attempted to correct the unfortunate impression that had been created by misstatements attributed to Drs. Condon and Weaver in a press interview. Although Mrs. Keener and Dr.

Meyerhoff have been asked to remain in their posts, they choose to withdraw in the interest of harmony and from a desire not to hamper the two administrations to follow that of Detlev W. Bronk, retiring president and chairman of the Board of Directors, whose administration they wholeheartedly support. Mrs. Keener has been with the Association since 1945 and has been executive editor of both journals since 1950. Dr. Meyerhoff succeeded the late F. R. Moulton as administrative secretary in January 1949, and had prior service as secretary of Section E (1937-40), elected member-at-large of the Council (1941-44), vice president and chairman of Section E (1944), and executive secretary (1945-46). No announcement has been made with reference either to their future plans or to their successors.

Alice I. Goldsby, of North Dakota Agricultural Experiment Station, has joined the staff of American Scientific Laboratories, Madison, Wis., as research parasitologist.

Bernhard Haurwitz, chairman and professor, Department of Meteorology and Oceanography, College of Engineering, New York University, has been named a member of the Committee on Geophysics and Geography of the Department of Defense Research and Development Board. Dr. Haurwitz has been a member of the committee's Panel on the Atmosphere for the past four years.

George W. Howard, chief of the Engineer Research and Development Laboratories, Fort Belvoir, Va., has received a \$15,000 Rockefeller Public Service Award, in recognition of outstanding public service. The award will enable Mr. Howard to spend a year visiting government and private research and development agencies in this country and abroad, to study methods of direction, planning, and management.

Wolfgang Huber, formerly group leader in organic chemistry, Sterling-Winthrop Research Institute, and, since 1945, director of chemical and biological research, Electronized Chemicals Corporation, has resigned as vice president of the corporation to enter practice as a management and research consultant. Dr. Huber recently organized a symposium on ionizing radiation at the Polytechnic Institute of Brooklyn.

Henry A. Knoll became dean of the Los Angeles College of Optometry on Feb. 2, succeeding Charles Sheard, interim dean since August 1952.

Albert K. Kurtz, on leave of absence from the Pennsylvania State College, is interim professor of psychology during the spring semester at the University of Florida.

John K. Northrop, aeronautical engineer and designer, has been retained on a part-time basis as a consultant to the president of the Garrett Corporation, Los Angeles. Mr. Northrop, who retired from the presidency of Northrop Aircraft, Inc., last November,

under doctor's orders, is undertaking a military product survey for AirResearch Manufacturing Company.

Louis J. Pecora has been appointed head of the Physiology Unit, Clinical Section, Occupational Health Field Headquarters, U. S. Public Health Service, Cincinnati. The unit is a newly created one and will be concerned with research in respiratory physiology and biochemistry, as related to industrial hazards.

Warren S. Peterson, of the Kaiser Aluminum & Chemical Corporation, Spokane, has been elected chairman of the American Chemical Society's new Inland Empire Section, which was formed to serve chemists and chemical engineers of eastern Washington and western Idaho. Other officers of the section are: chairman-elect, Herbert L. Redfield, of Kaiser Aluminum & Chemical; secretary-treasurer, Douglas R. MacIntyre, of Standard Oil Company of California, Spokane; counselor, Arthur L. McNeil, chairman, Department of Chemistry, Gonzaga University, Spokane.

Russell S. Poor has resumed his post as chairman of the University Relations Division of Oak Ridge Institute of Nuclear Studies, after a year's leave of absence. While on leave, Dr. Poor served with the National Science Foundation and with the University of Florida, where he directed a committee to plan integration of the proposed medical school with the university.

Howard S. Rappleye, chief, Section of Leveling, Division of Geodesy, will retire from the Coast and Geodetic Survey on Mar. 31, after more than 36 years of service. Mr. Rappleye plans to continue his research on various aspects of precision leveling.

Edwin A. Salmon, director of the New York University-Bellevue Medical Center, has announced his resignation because of ill health. **Donai Sheehan**, associate director, will administer the affairs of the center until the appointment of a new director, at which time Dr. Salmon's resignation will take effect.

Henry Tovey has been appointed senior literature chemist in charge of the Washington, D. C., Literature Research Branch of the Bjorksten Research Laboratories. Mr. Tovey replaces **James W. Perry**, who will remain in the organization as a consultant, and also in charge of a government-sponsored program for developing machine methods in searching and correlating scientific information.

The University of Sydney has conferred emeritus status on **W. L. Waterhouse**, who retired from the staff at the end of 1952, after 32 years of service with the Faculty of Agriculture. The council of the Royal Agricultural Society of New South Wales elected Dr. Waterhouse an honorary counselor, in recognition of his outstanding services to agriculture in Australia, especially in wheat improvement.

Education

Barnard-NBC Summer Institute of Radio and Television will be held June 29-Aug. 7. Both men and women may enroll, but they must be college graduates, or high school graduates with paid experience in radio or television. Full information and application forms (returnable by June 1) may be obtained from the institute, 401 Barnard Hall, New York 27.

George Washington University School of Engineering will offer, beginning next fall, a full curriculum leading to the Master of Engineering degree. Degrees awarded under the plan will be in general engineering, not in any particular field.

The **University of North Dakota** Medical School will establish, for the Department of Biochemistry, under the direction of W. E. Cornatzer and John P. Davison, the Guy and Bertha Ireland Laboratories for Cancer Research. The university has received a gift of \$11,200 for this purpose.

The **University of Pennsylvania** School of Nursing will hold a conference on "Current Concepts of Venereal Disease Control," May 25-June 6, in cooperation with the Institute for the Study of Venereal Diseases and the Public Health Service. The conference will be open to nurses and to instructors in U. S. schools of nursing.

Purdue University will hold its sixth annual Industrial Microbiology Institute, June 22-27, for scientists in industrial plants and others interested in the identification of fungi and the problem of fungus control. In addition to the usual lectures and laboratory sessions, a series of evening lectures will be given by Virgil G. Lilly, William J. Robbins, James G. Horsfall, Radcliffe F. Robinson, and J. H. Richardson.

Grants and Fellowships

The **AAAS Stillhamer Grant** has been awarded to Paul H. Ezell, a research associate of the Arizona State Museum, Tucson, for his project "The Acculturation of the Gila River Pimas." Mr. Ezell is at present in Mexico, where he expects to remain until the end of October, carrying out archival research on his project. The Department of Anthropology of the University of Arizona is the sponsoring institution.

The **American Heart Association** and its affiliates have awarded a total of \$285,400 to 51 scientific investigators in the form of fellowships for studies to begin July 1. The awards range from \$6000 to \$9000 for Established Investigators and from \$3500 to \$5500 for Research Fellowships. Victor Lorber, first AHA Career Investigator, has transferred his research activities from Western Reserve to the University of Minnesota.

The **W. K. Kellogg Foundation** has made a three-year grant of \$112,688 to the Harvard School of Public Health to finance a study that will explore the

problems of old age in terms of health and from the standpoint of welfare, recreation, and employment opportunities. Hugh R. Leavell, head of the Department of Public Health Practice and president-elect of the American Public Health Association, will be chairman of the faculty group that will work on the project.

Eli Lilly and Company have awarded grants to the Institute for Cancer Research, of Philadelphia, in support of the work of Irene C. Diller, and to the University of Tennessee in support of the studies of D. A. Shirley.

Muscular Dystrophy Associations of America, Inc., have awarded \$20,000 to Washington University, St. Louis, for projects under the direction of Edwin F. Gildea, and \$5000 to the University of Illinois College of Medicine, for investigations by Robert M. Kark.

National Multiple Sclerosis Society has made a grant of \$27,000 for the first year of a proposed two-year investigation at the University of Buffalo into the possible infectious origin of multiple sclerosis. The grant was made possible through a gift from Otto G. Frohnknecht, president of International Minerals and Metals Corporation, in memory of his daughter. Ernest Witebsky will direct the project.

In the Laboratories

The **Argonne Cancer Research Hospital** was opened at the University of Chicago Mar. 13 as part of its cancer research center. Built at a cost of \$4,200,000 by the Atomic Energy Commission, it will be under the direction of Leon O. Jacobson, professor of medicine; Robert J. Hasterlik will be associate director. Facilities of the hospital will be available to the Argonne National Laboratory and the 32 universities and other Midwestern institutions that are participating members of the laboratory.

Robert Busse & Co., 109 Broad St., New York, has been formed by Robert Busse, who recently resigned as vice president of Charles F. Hubbs & Co. after 23 years of service. Mr. Busse will concentrate on the development of plastics and papers for specialized uses.

New research physicists at **Los Alamos Scientific Laboratory** are Emerson Jones, of the University of Nebraska, and Samuel R. Orr, of Mound Laboratory, Miamisburg, Ohio; Joseph J. Petranto and Charles F. Sprague, III, have returned to Los Alamos from other employment.

Nuclear-Chicago will be used in the future to identify Nuclear Instrument & Chemical Corporation, because of the large number of firms with a similar corporate title.

Timber Engineering Company has added Norvelle G. Hundley, of the State University of New York College of Forestry, and Edward A. Mihok, of Trafford, Pa., to its research laboratory staff.

Meetings and Elections

The **American Academy of Tropical Medicine** has elected the following officers: president, Henry E. Meleney; vice president, George R. Callender; secretary, E. Harold Hinman; treasurer, Justin M. Andrews.

The **American Fern Society** has elected Ralph C. Benedict president, Donovan S. Correll vice president, Warren H. Wagner, Jr., secretary, and Matthew D. Mann, Jr., treasurer. The society has scheduled field meetings for May, June, July, and August, in Virginia, New York and New Jersey, Connecticut, and at Montreal, respectively. For September, a six-day field trip through northern Michigan, under the leadership of Dr. Wagner and Dale Hagenah, is being planned to precede the AIBS meeting in Madison, Sept. 6-10. For particulars, write Kathryn Boydston, Fernwood, R. D., Niles, Mich. Registration well in advance is advisable.

The **American Society for Metals** is sponsoring an all-day meeting at Purdue University, Apr. 25, to discuss "Modern Physical Metallurgy." Technical chairman of the meeting will be James B. Austin, director of the research laboratories of U. S. Steel and vice president of the society. Speakers will include Arthur E. Focke, General Electric Company; John R. Willard, Aluminum Company of America; and Arthur R. Lytle, Union Carbide and Carbon Laboratories.

A **European Symposium on Cortisone and the Suprarenal Cortex** is being organized in Milan by the Università degli Studi di Milano, sponsored by the Società Italiana di Reumatologia. The symposium, to be held Aug. 31-Sept. 2, will deal with biological and clinical topics in Italian, French, and English. For full information apply to C. B. Ballabio, Clinica Medica dell'Università di Milano, via F. Sforza 35, Milan.

The 19th annual **Field Conference of Pennsylvania Geologists** will be held at Lafayette College, May 29-31. Trips to the anthracite, slate, cement, and Triassic regions will be featured.

An all-day meeting of geologists, representing 13 Midwestern university geology departments, was held in February at the **Midwest Inter-Library Center** in Chicago to explore possibilities for the cooperative acquisition of little-used, but important, library materials in the field. The geologists decided that the 16 member-universities might appropriately supplement their own collections with a comprehensive collection of foreign geologic maps and with files of minor and less used journals, particularly those of foreign academies. Such material would be acquired by, and housed at, the center, for joint use.

The **Mississippi Academy of Sciences** will hold a meeting Apr. 24-25 at Mississippi State College as part of the college's Diamond Jubilee Celebration. Paul Klopsteg will make the banquet address.

Miscellaneous

Scientific research has progressed along several fronts in Australia in recent months. The appointment by the Commonwealth Government of an **Australian Atomic Energy Commission** was announced just before the end of the year. Its personnel will consist of J. E. S. Stevens, formerly secretary of the Department of Supply, who will serve as full-time chairman and executive officer; J. P. Baxter, professor of chemical engineering at the New South Wales University of Technology; and H. M. Murray, general manager of the Mount Lyell Mining Company Ltd. The commission will be responsible for all commonwealth activities connected with prospecting, mining, and processing uranium, as well as with the development of atomic energy for defense and industrial purposes. Following months of deliberation, a group of 24 prominent Australian scientists with the sympathetic cooperation of the Australian National Research Council has founded an **Australian Academy of Sciences**, which will parallel the Royal Society of Great Britain in its responsibilities and functions, and will be analogous to the National Academy of Sciences in the U. S. Headquarters will be at Canberra. The **Commonwealth Scientific and Industrial Research Organization** of Australia has announced the assignment of J. Griffiths Davies, associate chief of the Division of Plant Industry, to Brisbane, where he will take charge of the expanded CSIRO research program on agricultural problems in northern Australia. As revealed in the annual report for 1951-52, the Commonwealth Government is focusing a great deal of its attention on increased utilization of its tropical and desert areas. During the past two years Australian scientists have combed the African continent and the Mediterranean region of North Africa and Europe for new pasture and forage grasses that can be adapted to the Australian locale, and their search has included new varieties of crop plants. At the same time an intensive program of fundamental research on cloud physics, together with the development of techniques for artificial rain making, has been in progress. There is reason to believe that Australian scientists have carried their work in this field somewhat farther than scientists in this country. The CSIRO's Fourth Annual Report reveals the traditional concern with the commonwealth's pastoral and agricultural activities, but it also reports important advances in fuel research, and particularly in techniques designed to gasify brown coal, for the purpose of promoting Australia's chemical industry and preparing for the possible production of synthetic petroleum products.

The **Bernice P. Bishop Museum**, aided by a grant of \$15,200 from the National Science Foundation for the next 18 months, is now supporting the project "Insects of Micronesia," which was hitherto carried on by the Pacific Science Board with funds from the Office of Naval Research. The project is under the direction of J. Linsley Gressitt, and the results will be

published by the museum as a special series. About 400,000 specimens have been assembled from Micronesia, and these are being studied by more than 100 specialists representing some 50 institutions in a dozen countries. J. F. Gates Clarke, N. L. H. Krauss, and Dr. Gressitt have been completing the field work in the Caroline Islands under the ONR contract during 1952-53.

An **Institute for Pure and Applied Mathematics**, with Lelio I. Gama as director, has been founded in Rio de Janeiro by the National Research Council of Brazil. The new institute will sponsor the publication of the principal Brazilian mathematical journal, *Summa Brasiliensis Mathematicae*.

The **James F. Lincoln Arc Welding Foundation**, Cleveland 17, Ohio, is offering a total of \$30,000 in 101 cash awards for the best papers describing the mechanical design and construction of any type of machine or machine component designed for arc-welded steel fabrication. Top award is \$2000. A rules and conditions brochure for the contest, which closes *July 27*, is available from the foundation.

Recent visitors from abroad at the **National Bureau of Standards** included A. E. Ferguson, University of Melbourne; S. Sambursky, Research Council of Israel; Yuichi Makino, Kawasaki, Japan; Paulo Gomes de Paula Leite, National College of Engineering, Brazil; F. Reimers, Copenhagen; and G. Suckling and N. S. Grace, Toronto.

The *Proceedings of the Fourth International Congress on Mental Health*, held in Mexico City in December 1951, have been published in English and Spanish. The English edition, proceeds from the sale of which Alfonso Millan has agreed to contribute to the World Federation for Mental Health, is available from Columbia University Press at \$5.00 per copy.

Chemicals wanted by the **Registry of Rare Chemicals**, 35 W. 33rd St., Chicago 16, Ill., include: lead zirconate; beryllium molybdate; trimethylboron; divinyl sulfone; 4-hydroxynicotinic acid; camphanilane; cyclobutene; cyclobutyl dimethylamine; eicosanol; 1,2,3,4-tetrahydro-6-methoxyquinoline; 2,4,2',4',2'',4''-hexamethoxytriphenylcarbinol; 12-methoxystearic acid; methyl β -methylmercaptopropionate; arachidic acid; amoidin; brassicasterol; stigmasteryl acetate; androsterone; and lithocholic acid.

The **Royal Society (London)** and the **British Academy** have published in pamphlet form the results of the examination by the Abstracting Services Consultative Committee on transliteration systems. Entitled *The Transliteration of Russian, Serbian and Bulgarian for Bibliographical Purposes*, the pamphlet is available at 1s. from the Royal Society, Burlington House, Piccadilly, London, W. 1. The system outlined will be adopted in the society's publications.

Technical Papers

Eocene Foraminifera from Guam, and their Implications¹

Preston E. Cloud, Jr., and W. Storrs Cole

Geological Survey, U. S. Department of the Interior,
Washington, D. C., and Cornell University,
Ithaca, New York

Well-preserved and abundant upper Eocene Foraminifera from the matrix of water-laid tuffaceous rocks on Guam have a significant bearing on the geologic history of that island and of the Mariana island-arc as a whole (Fig. 1).

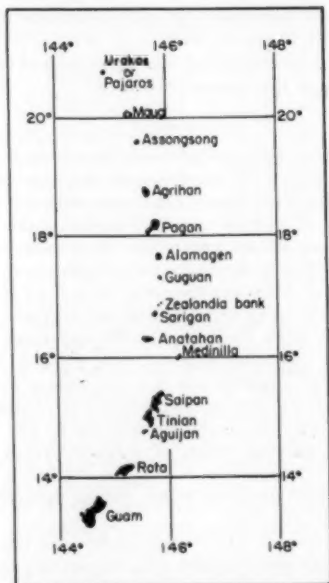


FIG. 1. Mariana Islands.

Stearns (1) divided the volcanic rocks of Guam into a lower effusive phase and an upper pyroclastic phase and stated that Miocene Foraminifera were associated with the pyroclastics. Cloud (2) suggested that the volcanic succession might be in part as old as Eocene, but accepted as a fact the report that Miocene Foraminifera were associated with some part of the volcanic succession. Results of additional field work by Cloud, after his report was submitted in late 1948, indicate that the lower Miocene rocks from which Cole (3) described Tertiary *e* Foraminifera are locally, and perhaps at all places, younger than known rocks of primary volcanic origin on Guam. Doubt is now

felt as to the likelihood that any Miocene Foraminifera are actually associated with primary volcanic rocks on the island. Reworking of older volcanic sediments, in combination with recent leaching of interstitial calcium carbonate, accounts for the resemblance to primary pyroclastic rocks of many of the Miocene strata on Guam and other Mariana islands.

Recent studies by Cole have established the late Eocene age of Foraminifera collected by Cloud and R. G. Schmidt in 1948 from tuffaceous beds in west-central Guam. The fossils occur as free specimens in the matrix of soft, deeply weathered granule breccia and conglomerate that contain many rounded limestone pebbles and dip about 5° south. The locality, MGC-5, is a road cut on a ridge crest between Mount Tenjo and Mount Alifan. Similar Foraminifera, as yet not carefully studied, were collected from a second locality (MGC-4) 750 ft farther north along the same road, in pebble beds that contain both limestone and volcanic fragments, dip about 50°-70° south, and are associated with calcareous tuff and tuffaceous limestone.

Only the Foraminifera from locality MGC-5 are here considered, and some of the species from this locality have not yet been identified. However, the late Eocene age of this fauna, and its regional correlation with zone *b* of the Indonesian Tertiary, are established by the presence of *Pellatispira glabra* Umbgrove, *Biplanispira mirabilis* Umbgrove, and *B. absurda* Umbgrove, in association with two or more species of *Asterocyclina* and two species of *Camerina*. In addition to the species listed, numerous specimens of an *Operculina* are tentatively identified as *O. pacifica* Whipple, and other specimens are referred to *Heterostegina* sp. It is of interest that one of the species of *Camerina* is a reticulate form closely related to *C. fichteli* (Michelotti), a marker for zone *c*, or lower Oligocene, in Indonesia. Although reticulate camerinids are not known to occur below zone *c* in the Indonesian Tertiary (4), this type of camerinid does occur in the Eocene of Europe (5). Its association with *Pellatispira*, *Biplanispira*, and *Asterocyclina* indicates a late Eocene age for the reticulate camerinid on Guam.

The observed sedimentary features of the strata at the outcrops described could be attributed either to the initial settling of primary pyroclastic debris in a marine environment, or to its reworking. However, the abundance of excellently preserved free specimens of Foraminifera several millimeters in diameter is conclusive evidence against the secondary derivation of these fossils. Thus, the time of final settling of the sediments to the beds in which they are now found is established as late Eocene. The volcanic fragments therefore can be no younger than late Eocene, and no pre-Eocene deposits have yet been recognized on other Mariana islands (6).

¹ Publication authorized by the Director, U. S. Geological Survey.

Evidence of an Eocene age for volcanism on Guam is consistent with evidence on age of volcanism from other Mariana islands south of 16° north latitude (Fig. 1). Conclusive evidence of post-Eocene volcanism in the Marianas has not yet been found on islands to the south of the young volcanic chain that ranges northward from Anatahan. Rocks of Oligocene age are as yet unrecognized in these islands, volcanic materials of known Miocene age can be interpreted as reworked from Eocene deposits, and younger rocks and sediments in no way suggest volcanic affinities. If, however, volcanic rocks younger than Eocene, or any rocks of Oligocene age, are to be found in the Marianas, Guam is a good place to look for them. The reticulate camerinid of the fauna here noted has an "Oligocene flavor," and succeeding rocks in a normal sequence might grade to the Oligocene.

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Audiogenic Seizure and the Adrenal Cortex

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This study was designed to test the hypothesis that ACTH injections sufficient to increase adrenal cortical size modify the susceptibility of rats to audiogenic seizure (hereafter designated AGS). The rationale of the use of ACTH in relation to AGS susceptibility is that both endogenous and exogenous ACTH and adrenal cortical hormones have been shown to be important in the adjustment and adaptation of mammals to stress of physical, physiological, and psychological origin. The behavioral relevance of adrenal cortical function in stress adaptation has been discussed by Hoagland (1). The AGS situation can be conceived as stressful from two points of view: first, the environmental conditions used to produce it—exposure to intense sound while closely confined; and second, from the standpoint of the behavior of the rat displaying a complete audiogenic seizure. Such an animal releases tremendous amounts of energy in a severe bout of running and a subsequent tonic-clonic convulsion. Furthermore, the catatonic state which sometimes terminates the abnormal behavior probably overles a state of increased energy mobilization.

In the experiment described here, 80 male and female hooded rats, approximately 40 days old, and

obtained from a colony maintained at the Louisiana State University psychology laboratory, were used.

The seizure box was 48 in. high by 26 in. wide and was constructed of double layers of plywood insulated in the middle with asbestos. A double glass window in the top permitted observation of the subjects at all times. Within the box was the actual seizure chamber, a metal cylinder 28 in. high, with a diameter of 14 in. The sound source, consisting of two 3-in. electric bells operating off a 6-v transformer, was placed under the perforated floor of the cylinder 6 in. from the rats. The entire apparatus was constructed in such a fashion as to reduce extraneous stimuli to a minimum. Light was supplied by a 6-v bulb in the top of the box, so arranged as to maintain a constant visual field overhead; hence, distractions from the observation window were reduced to a minimum. All electric controls for the seizure box were located on an instrument panel on top of the box.

The adrenocorticotrophic hormone used in this study was equal to the Armour Standard.¹

PHASE A

1. *Test for AGS susceptibility.* Seizure susceptibility was determined by one diagnostic exposure to sound stimulation. Preliminary experience with the particular strain of animals used indicated that the level of AGS susceptibility within the strain was approximately 50% with respect to the stimulus used. A 50% incidence of AGS was desirable, since it presented an equal opportunity for the detection of increasing or decreasing AGS frequency in the experimental animals. The diagnostic exposure was given 4 days before ACTH injection and was the animal's first experimental exposure to intense sound stimulation. The time interval was chosen to rule out as far as possible any spacing effects of seizures. There is evidence of refractoriness to seizures following massed seizures, but any such effect should dissipate in 4 days (2).

2. *Injection of ACTH.* Susceptible and nonsusceptible animals were equated with respect to weight and sex and assigned to one of four experimental groups. Group I consisted of susceptible animals that received injections of ACTH, Group II of susceptible animals that received injections of water, Group III of nonsusceptible animals that received injections of ACTH, and Group IV of nonsusceptible animals that received injections of water. Ten animals were assigned to each group. The animals receiving ACTH were given 2 mg standard ACTH subcutaneously, and the control animals were given an equal volume of water subcutaneously. The procedure was repeated at 4-hr intervals until three doses totaling 6 mg of standard ACTH had been given.

3. *Seizure test.* Two hr after the last injection of ACTH or water the animals in Phase A were subjected to 2 min of sound stimulation. If a seizure oc-

¹ We are indebted to Irby Bundling, of the Armour Laboratories, for providing the ACTH used in this study.

occurred within this period of stimulation, it was allowed to go to completion and the latency, duration, and type of seizure were recorded. Seizure latency was defined as the interval from the activation of the sound source until a seizure began. A seizure was defined as beginning with either explosive running or convulsions. Duration of seizure was defined as the time interval elapsing between onset of seizure as defined above and exhaustion or coma. Seizures were typed with respect to severity and presence or absence of catatonia and coma.

4. *Gland assay.* Ten hr postseizure (12 hr following the last injection of ACTH or H₂O) all animals were killed, and their adrenal glands removed. Immediately following removal, the glands were cleaned of the adhering fat and connective tissue and weighed. This was done immediately after removal in an effort to minimize variability resulting from loss of moisture after removal from the animal.

PHASE B

Phase B of the study was carried out to discover the effect on size of the glands of a seizure test 12 hr prior to removal of adrenal glands. The only difference between Phase A and Phase B is that, in Phase B, AGS-susceptibility tests (Step 3) were omitted.

RESULTS

In Phase A, all the susceptible animals that got ACTH had seizures upon presentation of the auditory stimulus. Eight of the 10 susceptible animals that received water had an AGS when sound was presented. In no case did an animal that had been previously classified as nonsusceptible have a seizure when sound stimulation was presented. The results indicate that the amount of ACTH used in this study has little effect upon the incidence of audiogenic seizure when administered to animals of known seizure susceptibility. This conclusion is further supported by the fact that no difference in latency, duration, or severity of seizures was noted between susceptible animals that received ACTH and those that received water.

Table 1 gives the means and standard deviations of the percentage body weights of the adrenal glands of the eight groups of rats. Percentage body weights

(total adrenal wt/body wt $\times 100$) were used in order to correct for differences in body weight. It will be noted in Table 1 that the ACTH-injected rats possessed larger adrenal glands than the control rats, the susceptible rats appear to possess larger adrenal glands than the nonsusceptible animals, independent of ACTH injection, and Phase A gland sizes do not differ systematically from Phase B gland weights. Each of these interpretations was tested by analysis of variance, the results of which are presented in Table 2. Table 2 shows that the ACTH gland weights

TABLE 2
ANALYSIS OF VARIANCE OF PERCENTAGE BODY WEIGHTS OF ADRENAL GLANDS FOR EIGHT GROUPS OF SUBJECTS TESTED UNDER DIFFERENT CONDITIONS

Source of variation	S.S.	df	Mean square	<i>f</i> ^a
ACTH vs. H ₂ O	24,657	1	24,657	8.39
Susceptible vs. non-susceptible	21,550	1	21,550	7.28
Seizure-no seizure test	195	1	195	
Interaction seizure test \times susceptibility	10.31	1	10.31	
Interaction seizure-no seizure test \times ACTH-H ₂ O	18.12	1	18.12	
Interaction susceptible-nonsusceptible \times ACTH H ₂ O	1.09	1	1.09	
Interaction susceptible-nonsusceptible \times ACTH-H ₂ O \times seizure test	43,240	1	43,240	14.60
Within groups	154,006	72	2,962	
Total	243,677	79		

^a The value of *f*, was not computed where the mean square between groups was obviously smaller than the mean square within groups. Only those *f* ratios in excess of the 1% level are given.

differ significantly from the control glands, thus indicating the efficacy of the ACTH injections as stimulants of the adrenal cortices. Table 2 also reveals that a significant difference exists between the adrenal weights of susceptible and nonsusceptible rats. The analysis of variance indicates no statistically significant difference between the glands of animals under-

TABLE 1
MEANS AND STANDARD DEVIATIONS OF PERCENTAGE BODY WEIGHTS OF ADRENAL GLANDS

Group	Phase A N = 40				Phase B N = 40			
	Seizure test following injection				No-seizure test following injection			
	Susceptible		Nonsusceptible		Susceptible		Nonsusceptible	
	ACTH	H ₂ O	ACTH	H ₂ O	ACTH	H ₂ O	ACTH	H ₂ O
	I	II	III	IV	V	VI	VII	VIII
Mean percentage body weight of adrenal glands	.0405	.0313	.0331	.0280	.0333	.0350	.0337	.0322
Standard deviation	.0037	.0042	.0050	.0027	.0050	.0063	.0035	.0037

going two seizures in a 4-day period (Phase A) and rats undergoing only one seizure 4 days before gland removal (Phase B). Having a seizure 12 hr before gland removal did not contribute to gland weight. Finally, it will be seen that the only significant interaction was the triple interaction among susceptible-nonsusceptible, ACTH-water, and the Phase A-Phase B variables. This calls for an intensive experimental analysis of the relatedness of these three sets of factors.

The initial problem set for this investigation was the determination of the effect of adrenal cortical stimulation on the AGS susceptibility of laboratory rats. This problem was attacked in Phase A of the present study, and results indicate that ACTH injections sufficient to increase the weight of the adrenal gland produce no reliable change in the AGS susceptibility of either susceptible or nonsusceptible rats.

It is of interest that the adrenal glands of the AGS-susceptible groups are heavier than those of the non-susceptible groups. It is possible that rats undergoing AGS have larger glands as a result of the seizure. The seizures induced in these animals are characterized by severe explosive bouts of running, followed by tonic-clonic convulsions, and terminating in a state of catatonia. This tremendous, though short-lived, energy release may be sufficient to produce adrenal cortical hypertrophy. It will be recalled that the adrenal glands were removed from half the rats (Phase A) 12 hr after the second of two seizure tests (the first having been 4 days before the second), and from half the rats (Phase B) $4\frac{1}{2}$ days after a single seizure test. If a seizure-induced adrenal cortical hypertrophy exists, it is doubtful if 12 hr, or even $4\frac{1}{2}$ days would result in a complete return to normal adrenal cortical weight. On the other hand, if seizure-induced cortical hypertrophy does occur, there might be evidence of a summation of the effects of the two separate seizures. No such trend was found in these data. Examination of Tables 1 and 2 reveals no significant or suggestive signs of a summation of the two seizures. Absence of a summation effect following two seizures does not permit the assumption that the first seizure did not produce gland hypertrophy, however. If seizure behavior produces an increase in gland weight it may well be that this increase in weight reaches a limit after one seizure. Subsequent seizures might act as a similar physiological stimulant of the gland without producing further increments in gland weight. The possibility of seizure-induced cortical hypertrophy cannot be conclusively evaluated within this study. Future studies in this laboratory will be directed toward the question of whether larger adrenal glands precede or follow audiogenic seizures. If the latter is true it will be of biological interest that such a transient, though severe, bout of activity is sufficient to produce increased adrenal cortical weight. If future evidence indicates that AGS-susceptible rats have larger adrenal cortices than nonsusceptible rats, independent of seizure occurrence, it will be an interest-

ing and provocative correlation of a biological and behavioral characteristic. Other studies have suggested a relationship between the adrenal cortex and convulsive seizure threshold, frequency, and severity. Griffiths (3) observed that adrenalectomy reduced either seizure incidence or severity in rats. Woodbury and Sayers (4) have shown that both ACTH and cortisone lower the electroconvulsive threshold in rats pretreated with desoxycorticosterone. These studies suggest the need for exploration of the possibility that seizure-susceptible rats have larger adrenal cortices than nonsusceptibles, independent of any immediate effect of the seizure.

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Nutritive Value of Rust-infected Leaves

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The habit of certain snails, slugs, beetles, and insect larvae of eating the rusted areas of bean, broad bean, or snapdragon leaves or stems in preference to the healthy portions of these plants suggested that rusted tissues might have unique nutritive properties. The reported salutary effect of rusted tissues on farm animals and man (1); the greater invasiveness of a powdery mildew (2), of several viruses (3), and of *Fusaria* (4), in rusted than in normal tissues; the collection of rust spores by bees (5); and the high carotene content of rusted leaves (6), all support this idea.

Microbiological assay (7) of primary pinto bean (*Phaseolus vulgaris*) leaves infected with rust (*Uromyces phaseoli*) revealed a higher pantothenic acid content in rusted than in healthy leaves (Fig. 1). The pantothenic acid content of inoculated leaves increased up to at least 12 days after inoculation, at which time it was about 10 times as great as that of normal leaves. Rust uredospores alone showed 45 γ pantothenic acid/g spores, and it might therefore seem that the pantothenic acid of rusted leaves was primarily localized in the rust mycelium and spores. No clear difference between healthy and rusted leaves with respect to thiamin, riboflavin, folic acid, or niacin content was detected in a preliminary test.

Snails (*Helix aspersa*) ranging from 0.3 to 8 g in weight were confined singly in pint jars or large Petri dishes with healthy bean leaves and/or with bean leaves inoculated 6-10 days previously with

rust. The leaves and snails were weighed before and after a 2-day confinement period. Most trials were in a light laboratory at about 20° C, but two trials at 13°, 19°, and 25° C showed greater gains per unit of food consumed at 13° than at 19° and greater gains at 19° than at 25° C. Small snails made greater relative gains than large ones. Of 20 snails confined with healthy and rusted leaves in the same dish, 3 ate from healthy leaves only, 9 ate from rusted leaves only, 3 ate from both healthy and rusted leaves, and 5 selected neither. Twenty-five snails confined with healthy leaves alone gained 12% of their original weight and 0.34 g for each gram fresh weight of leaves consumed, and in the same tests 25 snails confined with rusted leaves gained 15% of their original weight and 0.45 g for each gram of leaves consumed.

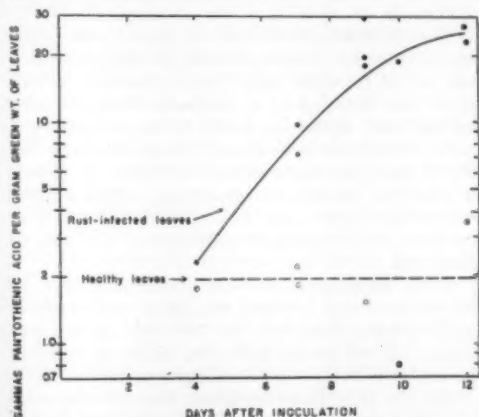


FIG. 1. The pantothenic acid content of healthy and rust-infected bean leaves at different times after inoculation.

In other trials bean leaves were sprayed with calcium pantothenate (CaP) solution to give about 1 mg CaP/g green weight of leaves. After the spray deposit had dried the CaP-sprayed and control leaves were offered separately to snails. The 13 control snails gained 7% of their original weight and 0.30 g/g of leaves consumed, whereas the 10 snails fed CaP-treated leaves gained 14% of their original weight, or 0.51 g/g leaves consumed.

Thirteen *Diabrotica* beetles confined for 3 days with both healthy and rusted leaves ate about 3 times as much leaf area from the rusted as from the healthy leaves, but in another test 5 *Diabrotica* beetles ate less from leaves bearing 1 mg CaP/g of leaves than from unsprayed leaves.

Ten rats (*Rattus norvegicus*) were maintained on a pantothenic acid-deficient diet (8) supplemented with biotin and folic acid for 39 days after weaning, for depletion of their vitamin stores. From these 10, 3 matched pairs of litter mates were selected. One of each pair was then given a daily supplement of 1 g dried healthy bean leaves, for a period of 18

days, and its litter mate was given a daily supplement of 1 g dried rusted bean leaves. The rats given the healthy bean leaves lost an average of 0.2 g/rat/day, whereas the rats given the rusted leaves gained an average of 5.3 g/rat/day. In contrast to this, rats on a protein-free diet, but fed dried rusted bean leaves *ad lib*, showed no significant difference in growth rate from rats given dried healthy leaves *ad lib*.

In nine trials in which CaP was added to a water suspension of crude tobacco mosaic virus (TMV) inoculum, the numbers of local virus lesions resulting on bean was consistently increased over the controls without CaP. The optimum concentration was not sharply defined but seemed to be about 1% CaP, which gave an average of 1.8 times as many lesions as the control.

When bean leaves were inoculated with TMV, detached, and incubated with the upper inoculated surfaces resting on water, very few if any virus lesions developed. This is another aspect of the inhibiting action of water in virus inoculations (9). When the leaves were placed with the inoculated surface on 3% CaP instead of water, large numbers of lesions developed. Apparently CaP offset the effect of water.

When young primary bean leaves from plants 7–10 days after seeding were inoculated with TMV on their upper surfaces, detached, and floated with their lower surfaces on 3% CaP in a light laboratory at about 20°C, the number of local virus lesions was commonly greater and the size of the lesions was consistently larger than for control leaves on water. In one representative test the assayed amount of virus in leaves incubated on 3% CaP was 7 times as great as for leaves incubated on water.

A similar or much greater increase in number and/or size of lesions and assayed amount of virus resulted when inoculated bean leaves were incubated on 0.001% $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 0.01% $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, or 0.00003% AgNO_3 . This might seem to confirm with TMV on bean the apparent similarity in effect of copper and pantothenic acid as observed with rats (10), but evidence against this hypothesis is beyond the scope of this report. The above effects were not observed with old leaves or with leaves incubated at 31°C.

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The Nature of Genetic Resistance to Infection in Mice¹

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Selection experiments have been devised to show the relation of total leucocyte count and blood pH in mice to resistance to mouse typhoid. Results of Hill *et al.* (1), with respect to resistance of mice to endotoxins, have also been considered.

A number of inbred strains of mice exhibit characteristic and relatively stable responses to infection with *Salmonella typhimurium*. The Iowa State College genetics laboratory, for example, maintains 12 such strains, 6 of which have been utilized over a period of years to investigate the physical basis of natural resistance (2). A rather definite picture has emerged. In general, resistant strains differ from susceptible in possessing relatively higher leucocyte counts (3), higher blood pH (4), and greater resistance to the toxic effects of massive doses of heat-killed organisms (5).

Since the mouse strains employed by J. W. Gowen and others were first differentiated on a basis of resistance or susceptibility to mouse typhoid, they are unsuitable for critical evaluation of independent contributions of single mechanisms to the over-all resistance complex. To attack this aspect of the problem, selection experiments were inaugurated at the University of Saskatchewan in 1949 to produce a high leucocyte line (LCH) and a low leucocyte line (LCL) and to produce high and low blood pH lines (pHH and pHL). MacArthur's random-bred mice (6) were

chosen as the initial breeding stock, since they were originally derived from crossing 6 distinct laboratory strains, none of which had been previously employed in disease-resistance studies. They have been designated the T strain and are being maintained as an outbred control line. In 1950 the entire mouse colony was transferred to the University of Kansas, at which time some family lines were lost. Selection has been coupled with intensive inbreeding, mostly by full-sib matings.

Divergence of high and low leucocyte lines under the influence of selection with inbreeding is illustrated in Table 1. Since age is a major source of nongenetic variation, counts were made when mice were 30 days old or within 2 or 3 days of that age. Metrical bias, resulting from peculiarities associated with the technique of bleeding from the tail, is judged to be of no importance, since the order of magnitude of differences between strains was not altered when blood was collected by cardiac puncture or when procedure was varied in other ways. Data presented in this paper were obtained by a standard technique involving tail blood, so that our actual figures are not necessarily comparable with those of other workers. We believe that systematic errors are likely to persist in long-term experiments despite all efforts at randomization, but by using controls and, in the case of resistance tests, repeating experiments, bias can be minimized.

It was not feasible to count T mice each time the selected mice were counted, but counts were made at the same time as the 2nd, 5th, and 10th selected generations. It will be noted that the mean cell count in the outbred T line has remained reasonably stable (Table 1). It is therefore likely that environmental factors contribute relatively little to the variance attributable to differences between generations.

TABLE 1
SELECTION FOR HIGH AND LOW LEUCOCYTE COUNTS IN MICE
(Total Leucocyte Counts/mm³ from Tail Blood)

Generation	LCH strain			LCL strain			Difference LCH-LCL	T strain		
	No. of mice	Mean cell count	SE	No. of mice	Mean cell count	SE		No. of mice	Mean cell count	SE
0								118	9,599 ± 288	
1	73	9,564 ± 340		82	7,956 ± 366		1,608			
2	73	9,169 ± 414		86	7,299 ± 273		1,870	30	9,503 ± 787	
3	107	8,685 ± 309		97	6,321 ± 228		2,364			
4	147	10,470 ± 274		143	7,769 ± 172		2,701			
5	97	11,520 ± 456		103	8,074 ± 257		3,446	43	8,212 ± 460	
6	32	13,902 ± 717		74	6,539 ± 309		7,363			
7	96	13,832 ± 482		78	6,767 ± 293		7,065	118	9,482 ± 308	
8	132	14,710 ± 379		43	7,103 ± 427		7,607			
9	89	15,021 ± 407		101	5,729 ± 273		9,292			
10	105	15,525 ± 524		154	6,674 ± 194		8,851	131	8,798 ± 250	

¹ Supported by grants from the Saskatchewan Research Council, the National Research Council of Canada, and research grant (G-3141) from the National Institutes of Health, USPHS.

² With the technical assistance of Barbara Myers.

Differential counts made on blood from mice of generations 7, 8, and 9 showed consistent differences between LCH and LCL lines, with LCH mice exhibiting higher lymphocyte and lower neutrophil propor-

TABLE 2
DIFFERENTIAL LEUCOCYTE COUNTS FOR 3 GENERATIONS
OF LCH AND LCL MICE

Generation	Mouse strain	No. of mice	Lymphocytes	Monocytes	Neutrophils	Eosinophils
7	LCH	68	84.5	1.1	12.8	1.5
	LCL	26	82.8	3.3	13.0	.8
8	LCH	129	90.9	1.2	7.2	.6
	LCL	43	86.7	1.5	10.7	.8
9	LCH	80	90.8	.5	8.3	.4
	LCL	84	84.8	.7	14.0	.5
7, 8, and 9	LCH	277	89.3	1.0	8.9	.8
	LCL	153	85.0	1.4	12.9	.7

tions than LCL mice. Degenerate leucocytes, which were enumerated separately, were more numerous in the high line (4.6%) than in the low (2.6%). Results are shown in Table 2. Despite the differences in differential counts, the LCH strain exceeded the LCL in all categories on a basis of absolute numbers of cells, indicating that selection was effective for all types of cells.

We were confident at the outset that high line animals would be relatively resistant and low line ones relatively susceptible to mouse typhoid. In fact, early tests, involving small numbers, did suggest such an interpretation, which was reported (7). It is now evident that the predicted relationships do not hold. High line mice do differ from lows in resistance to mouse typhoid but in an inverse manner. The data concerning inoculation tests, employing 200,000 live organisms of *S. typhimurium*, are summarized in Table 3. The first three tests were done at the University of Saskatchewan, the last three at the University of Kansas; the main difference involved a change to a strain of pathogen of lower virulence. Experimental control over dosage and other nongenetic variables was effective, as evidenced by repeatability in the T

TABLE 3
SURVIVAL OF LCH, LCL, AND T MICE FOLLOWING
INTRAPERITONEAL INOCULATION WITH 200,000
LIVE ORGANISMS OF *S. typhimurium*

Test No.	Strain of pathogen	LCH		LCL		T		Inbred T	
		No. of mice	% survival	No. of mice	% survival	No. of mice	% survival	No. of mice	% survival
4	A-28	100	40.0	92	32.6	59	42.3		
5	A-28	21	19.0	23	39.0	32	41.0		
6	A-28	31	16.1	36	27.8	103	43.7		
7	B-1	64	18.8	130	24.6	169	72.8	35	51.4
8	B-1	61	36.1	15	20.0	42	83.3	7	28.6
11	B-1	48	27.1	51	33.3	62	56.4	45	42.2
		325		347		467		87	

strain, particularly in tests employing A-28 pathogen. It might be argued that the difference in resistance between the outbred T and the inbred LCH and LCL lines is a function of mating system and not related to leucocyte count per se. This view finds support in results of resistance tests employing an inbred line also derived from T, but in which no selection had been practiced (Table 3). Regardless of our interpretation of the data, it is evident that high leucocyte count does not, by itself, confer an advantage to the host from a standpoint of resistance to mouse typhoid. Genetically high leucocyte count mice were, in fact, at a disadvantage. It is therefore suggested that in the inbred lines employed by Gowen and Calhoun (3) genes have been fixed which affect quality of leucocytes, whereas in our selection experiment leucocyte number alone has been altered. Genetic differences in ability of leucocytes (8) and macrophages (9) to digest phagocytosed bacteria, as well as other qualitative properties of leucocytes, are known (10).

TABLE 4
SURVIVAL OF PHH, PHL, AND T MICE FOLLOWING
INTRAPERITONEAL INOCULATION WITH 200,000
LIVE ORGANISMS OF A-28 *S. typhimurium*

Test No.	pHH		pHL		T	
	No. mice	% survival	No. mice	% survival	No. mice	% survival
4	154	29.8	159	36.5	59	42.3
5	39	28.2	42	42.8	32	41.0

Although extenuating circumstances might be invoked to account for the results with respect to leucocytes, a different set of arguments would be necessary to explain an equally unsuspected relationship between blood pH and resistance. Again, starting with outbred T mice, selection and inbreeding were practiced to produce high and low lines, but in this case blood pH was the criterion of selection. Employing the technique described by Weir (4), Clark (11) was successful in one generation in separating out a high line (pH $7.47 \pm .005$) and a low line (pH $7.42 \pm .005$) from the T strain (pH $7.45 \pm .004$). Two additional generations of selection resulted in no appreciable change in the means. Also, inbreeding was no more effective than assortative mating in fixing genes affecting blood pH, indicating that the genetics of blood pH is not complex. Results of resistance tests employing a 200,000 dose of A-28 strain *S. typhimurium* are shown in Table 4. As in the case of leucocyte count, the high line proved to be more susceptible to mouse typhoid than did the low line, a result not to be anticipated on a priori grounds, in view of the positive correlation between blood pH and resistance reported to exist in the Iowa State College inbred mouse strains (4). The possibility of a subtle interaction between blood pH and the effectiveness of leucocytes cannot be precluded, but no correlation between leucocyte count and blood pH was found for 61 T mice tested for both

($r = .059$), indicating independent genetic determination of the two characters.

Finally, an independent example of the nonadditive nature of resistance components comes to us from the results of an investigation in which the aims were quite different from our own. Hill *et al.* (1), disturbed by the possibility that residual congenital passive immunity might influence inheritance studies, undertook to employ a partially purified toxic fraction isolated from *S. typhimurium*. As in our experiments, marked response to selection occurred. The survival rates among toxin-injected mice (combining 9th and 10th generations) were 64.2% for the selected group compared to 14.0% for the control group. When live organisms were employed on similar mice, either *per os* or intraperitoneally, the results were "very surprising." The genetically toxin-resistant mice were on the average uniformly more susceptible to the living organism than were the controls. Unfortunately the experiment was terminated by the outbreak of the war, but the parallel with our independent results concerning leucocytes and blood pH is striking.

To test the suggestive hypothesis that a physiological relationship between leucocyte count and toxin resistance might exist, mice of LCH, LCL, and T strains have been subjected to massive intraperitoneal injections of vaccine. The results have been negative in terms of the hypothesis. In the first experiment (Test 9) employing a dose of 2,000,000,000 killed organisms, survival rates were: LCH, 28%; LCL, 29%; T (inbred), 34%. In Test 10, with a dose of 1,500,000,000, survival rates were: LCH, 49%; LCL, 54%; T (inbred), 61%. Nearly all deaths occurred within 48 hr of inoculation. Although the mouse strains reacted in the same manner to toxins as to live organisms, there still existed a possibility that there might be strain differences in ability to acquire immunity. Accordingly, mice of the 3 strains were immunized by sublethal doses of vaccine and subsequently challenged with 200,000,000 live organisms. Survival rates were: LCH, 76%; LCL, 79%; T (outbred), 77%; T (inbred), 84%. This experiment has not been repeated, but the test involved 209 mice with approximately equal numbers per strain. Agglutination tests failed to show consistent strain differences in antibody titer.

Some degree of genetic resistance to a naturally occurring mouse disease, as a result of past natural selection, is to be expected in any population of mice. Moreover, components of resistance are likely to be balanced in some manner. Artificial selection, based on ability to survive infection, will accomplish essentially the same result as a naturally occurring epidemic and should also lead to balanced gene combinations. This will not be true in the case of selection experiments directed toward altering a single character unless this character is directly adaptive. If leucocyte number, for example, affected resistance in general, then selection for high count should lead to enhanced resistance. Our investigation supports the

view that resistance to mouse typhoid is dependent on complex interactions of characters which, taken individually, do not confer resistance to the host.

Nonspecific mechanisms of resistance to bacterial diseases are likely to be common to mice in general, so that isolation of genetic components will be possible only in those rare cases which involve a mutation in an essential gene. Lack of complement in guinea pigs, resulting from a defective recessive gene, affords an example (12). Complement-deficient animals were found so susceptible to a variety of diseases that the line could not be maintained even under laboratory conditions.

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A High-Temperature Strain of *Chlorella*

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Various strains of the green alga *Chlorella* have been used extensively for study of photosynthesis and other physiological processes. Such work has been restricted almost exclusively to temperatures at or below 25° C. The choice of lower temperatures, probably made on the basis of qualitative experience, is consistent with the ecological observation that "many algae do not survive a rise in temperature and thrive only in cold waters" (1).

Recent investigations on the mass culture of algae have demonstrated the difficulties of maintaining temperatures as low as 25° C in dense suspensions under sunlight illumination (e.g., [2]). An alga with a higher temperature optimum would be of obvious usefulness for both practical application to mass culture and experimental application to physiological studies. We are now able to report the isolation of a number of strains of *Chlorella* with higher temperature optima and the salient characteristics of one of the strains.

Samples from warm local surface waters were used to supply inocula for test tube cultures grown in a Knops solution at pH 6.8; the medium was provided with microelements and 0.5 g/liter of a chelating

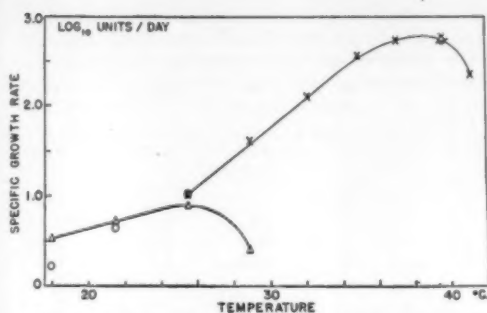


FIG. 1: Growth rate as a function of temperature. Δ , *Chlorococcoides pyrenoidosa* (Emerson's strain) at 1600 ft-c; \times , Tx 71105 at 1600 ft-c; \circ , Tx 71105 at 500 ft-c; \square , Tx 71105 at 2800 ft-c.

agent, ethylene diamine tetracetic acid, as previously described (3). The cultures were aerated with 4% carbon dioxide in air, illuminated at 500 ft-c by fluorescent lamps, and incubated at 32° C. After several serial transfers, samples were plated out on agar medium. Bacteria-free cultures were obtained from isolated colonies.

Preliminary study of 12 strains isolated at 32° C indicated that one of these (Tx 1105) would show rapid and continued growth at 39° C. After repeated culture at 39° C, a second plating-out yielded a second series of isolates. One of these (Tx 71105) was selected for further study, preliminary results of which are presented here. Subsequently a third series of isolates was obtained via accumulation cultures at 39° C. Among 61 original strains established there are significant differences in growth rate and in the tendency of the cells to clump in liquid cultures. Cells of the various strains are not readily distinguishable from the Emerson strain of *Chlorococcoides pyrenoidosa* in size, morphology, or mode of reproduction; at this time we prefer to regard them as strains of a species of *Chlorococcoides*.

Tx 71105 and the Emerson strain of *C. pyrenoidosa* have been submitted to a comparative study of the effect of temperature on the growth rate at light saturation. Growth in test tube cultures in photothermostats (as described above for the accumulation cultures) was determined in terms of the optical density measured by an Evelyn colorimeter with 600 m μ filter. The logarithm of the optical density plotted against time yields a straight line, the slope of which (k) is the specific growth rate. For *C. pyrenoidosa* the method yields a value for k of $0.85 \pm 0.05 \log_{10}$ u/day at 25° C, as compared to a value of 0.87 determined by the more elegant method of an automatic dilution device.

Light-saturation of growth of *C. pyrenoidosa* could be achieved by two banks of two 20-w daylight fluorescent lamps placed on each side of the photothermostat and delivering about 500 ft-c to opposite sides of the test tube cultures. This arrangement was adequate also for Tx 71105 at temperatures below 26° C. At

higher temperatures two banks of tungsten lamps delivering 1600 ft-c or 2800 ft-c to opposite sides of the cultures were used to obtain light-saturation.

Cultures for the growth measurements were inoculated from 3 units of a continuous-culture apparatus which contained Tx 71105 at 25° and 39° C and *C. pyrenoidosa* at 25° C. Test tube cultures held at the experimental temperature were continued by serial transfer until the growth rate remained constant over two successive attempts.

The results are presented in Fig. 1. The less extensive data for *C. pyrenoidosa* indicate a temperature optimum at 25°-26° C. In spite of repeated attempts we were unable to train *C. pyrenoidosa* to maintain a stable growth rate at temperatures higher than 30° C. The temperature optimum for Tx 71105 lies at about 39° C. A stable growth rate for this strain could not be obtained above 41.2° nor below 25.5° at 1600 ft-c. Reduction of the light intensity to 500 ft-c permitted a stable growth rate down to at least 21.5° C.

Preliminary manometric studies on Tx 71105 at 39° C have yielded maximum values of about 5 mm³ O₂/mm³ cells/hr for respiration and 100 mm³ O₂/mm³ cells/hr for photosynthesis, although in the latter case we are not certain that light-saturation was attained. This is the highest rate of photosynthesis per unit quantity of cell material of any organism so far observed.

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Metabolism and Removal of Ca⁴⁵ in Man¹

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This report deals with the metabolism and removal of Ca⁴⁵ in man, as studied by the administration of a single tracer dose of high specific activity radiocalcium. Although such data are available for animals (1-9), none has been reported for man. From the rate of disappearance of Ca⁴⁵ from the blood stream, its excretion, and its uptake and removal from bone, information on calcium metabolism may be obtained without disturbing the calcium homeostasis.

The sodium salt of ethylene diamine tetracetic

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² The assistance of Leonard Woldowsky and Agnes Hausinger is gratefully acknowledged.

TABLE 1
TISSUE ANALYSES*

	Ca (g%)	Ca ⁴⁵ ($\frac{\mu\text{c}}{\text{g}} \times 10^{-3}$)	Specific activity ($\mu\text{c/g Ca}^{45}$)	N (g%)	P (g%)	P corr† (g%)	Ca P corr†
Rib	18.31	12.6	0.069	3.55	8.29	8.05	2.28
Femur							
Cortex	22.57	5.9	0.026	2.44	9.71	9.54	2.37
Spongiosa	19.01	9.0	.047	3.96	9.25	8.98	2.06
" Tumor "	15.30	22.7	.148	6.00	9.04	8.63	1.69
Spongiosa adjacent to tumor	18.33	18.8	.103	7.07	9.45	8.96	1.95
Vertebra‡	9.53	5.31	0.056	7.88	5.63	5.09	1.69
							N
							P
Liver‡	0.40	0	—	12.25	0.81	—	15.1
Kidney‡	0.60	0	—	10.38	0.75	—	13.9

* Patient M. A. Analyses of tissues obtained at autopsy. Patient received 57.6 $\mu\text{c Ca}^{45}$ 14 days prior to death.

† P corr = Total P—P which is accounted for by nitrogen (N : P = 14.6).

‡ = Tissues dried but not defatted.

acid (EDTA), a strong chelating agent, forms complexes with calcium and other metallic ions (10-12). Marked excess calcinuria without lowering of serum calcium levels was observed in man following the slow intravenous administration of Na-EDTA (13), illustrating the demineralizing effect of this salt. The rate of such skeletal demineralization was studied by infusing Na-EDTA following the equilibration of a dose of radiocalcium.

In another series of experiments (not reported here) the injection of the calcium salt of EDTA induced an excess excretion of Ca^{45} and of metals (Pb, Y) deposited in bone (14, 15). Such data may indicate the quantity of calcium and of metallic ion available for surface exchange.

The studies were performed on patients⁴ under controlled conditions of the metabolic ward, while they were on a low calcium diet. Analyses of food and of excreta were performed as previously described (16). Upon the completion of the balance studies a tracer dose of $\text{Ca}^{45}\text{Cl}_2$ (0.75-100 $\mu\text{c/kg}$ body weight) was injected rapidly into the antecubital vein of the fasting patient. Blood samples were taken at short intervals from the femoral artery through a Courmand needle. Urine samples were obtained through an indwelling catheter at frequent intervals; the bladder was rinsed at the completion of each collection. Stool collections were made daily. On 3 days following the injection of radiocalcium, blood and urine were frequently assayed for Ca^{45} .

When the levels of Ca^{45} approximated an equilibrium in the serum and excreta, the sodium salt of EDTA was infused intravenously. Four g of the salt in 500 ml of 5% glucose in water was infused over a 6-hr period on 3 consecutive days.

Calcium 45 was determined in serum and urine

⁴ Authorization for the use of tracer doses of Ca^{45} in cancer patients only was granted through the Subcommittee on Human Applications, by the Isotope Division of the U. S. Atomic Energy Commission.

⁵ $\text{Ca}^{45}\text{Cl}_2$ in a solution containing 42 $\mu\text{c/mg}$ calcium was obtained from the Oak Ridge National Laboratory, Oak Ridge, Tenn.

on unashed samples and in stool on ashed samples. Occasionally, the presence of larger amounts of organic materials necessitated the dry-ashing of the urine. In one instance, bone obtained at autopsy was analyzed. The bone was first defatted by extraction with alcohol and ether and then dried to constant weight; weighed aliquots were ashed and analyzed for calcium, Ca^{45} , and other constituents (Table 1). Calcium 45 was precipitated as the calcium oxalate with 15 mg stable calcium added as carrier, and the precipitate was collected onto planchettes using especially constructed centrifuge tubes. The precipitate was air-dried and counted in a Q-gas flow counter. Correction for self-absorption was made by drying the precipitate to weight constancy and by using an absorption curve previously determined. A standard was prepared by adding a known amount of Ca^{45} to 1 ml of serum containing no activity and precipitating the Ca^{45} in the manner described. The lowest level of activity that could be determined was 0.0001 μc , with reproducibility of $\pm 5\%$.

The information obtained on the metabolism of Ca^{45} by this technique is illustrated by the following example. A patient with multiple myeloma and primary hyperparathyroidism was given 57.6 μc of Ca^{45} . The metabolic balance studies disclosed a rapid rate of demineralization, with an average daily urinary calcium excretion of 334 mg. Fig. 1 shows the rapid disappearance of Ca^{45} from the circulation and its prompt excretion in the urine. Five min after the administration of Ca^{45} only 26% of the dose was found in the circulation when calculated on the basis of a plasma volume of 2500 ml.⁵ Thereafter, the disappearance rate gradually decreased; 4.3% of the injected dose was present after 24 hr. The radiocalcium appeared rapidly in the urine. Within 30 min 0.64%, and after 24 hr 7.4%, of the injected dose had been excreted. The feces collected for 2 days after the injection contained 0.8% of the dose. Near

⁵ This rapid decline is attributable to equilibration of the injected dose with calcium in the extracellular fluid space.

equilibrium was reached in the blood 2 days after the injection. In 14 days a total of 40.4% of the administered dose was accounted for: 0.9% remained in the serum, 32.7% had been excreted in urine, and 6.8% in the stool. Thus, 34.6 μ c was retained in the tissues.

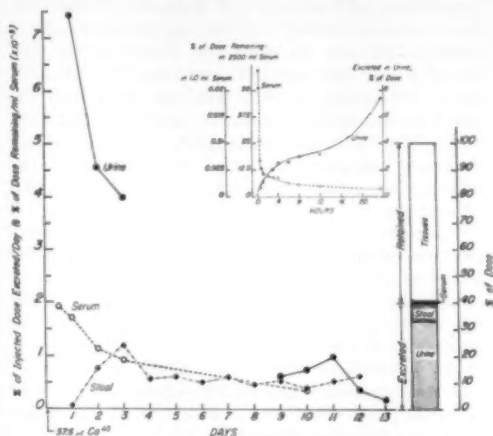


FIG. 1. Patient M. A. Serum levels, urine and fecal excretion of Ca^{45} following intravenous injection of 57.6 μ c. Bar diagram shows the distribution of the dose at the time of death.

Fourteen days after the administration of radio-calcium the patient died of an intercurrent fulminating pneumonitis. Table 1 represents the analysis for Ca^{45} of samples of bone and of tumor and other tissues obtained at autopsy. Significant amounts of Ca^{45} were found in all bone samples and in the tumor. None was found in the liver and kidneys. The specific activity of 4 of the bone samples varied from 0.026 to 0.069 μ c Ca^{45} /g Ca, but the concentration of Ca^{45} was considerably higher in the myelomatous tissue and in the adjacent spongiosa. The Ca^{45} content of the skeletal mass, estimated⁶ on the basis of this bone analysis is in fair agreement with the amount of Ca^{45} retained in the body.

The removal of the administered Ca^{45} induced by the infusion of Na-EDTA⁷ is illustrated in Fig. 2; 57.6 μ c Ca^{45} was administered to a patient with prostatic cancer and osteoblastic metastases. On 3 days preceding the infusion of Na-EDTA, urine samples were analyzed daily at 6-hr intervals. In contrast to samples from the patient mentioned above, these showed an extremely low excretion of both stable and radioactive calcium. Fifteen days after the administration of the isotope, 4 g Na-

EDTA was infused for 6 hr on 3 consecutive days. The daily urine collections, fractionated as above, showed the excretion of both calcium and Ca^{45} increased more than tenfold to 0.2% of the dose/day. The maximum excretion was noted during and shortly after the completion of the infusion. Twenty-four hr later, the excretions were only slightly above the preinfusion levels. There were no changes in the oxalate-precipitable calcium content of the serum.

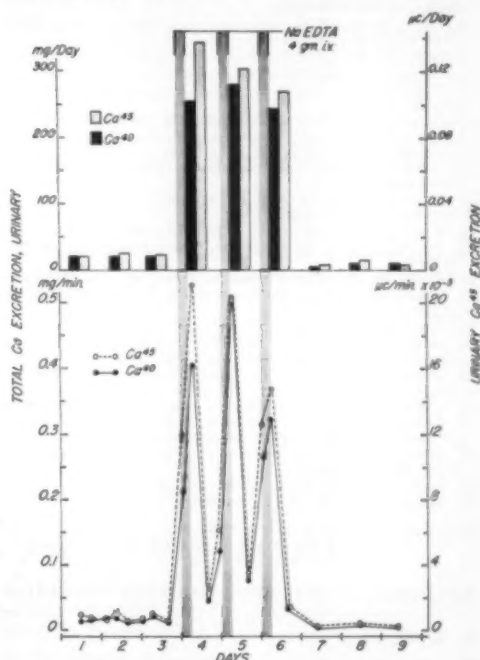


FIG. 2. Patient E. S. Urinary Ca^{45} and Ca^{40} excretions following intravenous infusion of 4 g/day of the sodium salt of ethylene diamine tetracetic acid.

In the experiment illustrated in Fig. 1 and Table 1, it was shown that Ca^{45} rapidly disappears from the blood stream, appears in the excreta, and is deposited in bone. The rate at which these processes take place may vary depending on the state of bone metabolism, and may represent a more useful indicator of skeletal activity than the criteria heretofore employed—such as metabolic balance studies and the calcium-tolerance test (18). Indeed, in a series of experiments, the sensitivity of such measurements was indicated (19). From the fraction of Ca^{45} recovered from the excreta following the intravenous and/or oral administration of Ca^{45} , the endogenous fecal calcium and the rate of utilization of ingested calcium may be estimated.

The excess excretion of Ca^{45} which follows the administration of Na-EDTA is shown in Fig. 2. Since the ratio of the excreted Ca^{45} /Ca remains unchanged,

⁶ The total body calcium of a normal adult of 70 kg body weight is estimated to be 1160 g (17). The body calcium of this patient was estimated to be 976 g; the total amount of Ca^{45} retained in the skeleton, calculated on the basis of the analysis of 4 bone samples with the average specific activity of 0.05 μ c/g calcium, was 48.8 μ c; the actual amount retained was 34.6 μ c.

⁷ The EDTA was supplied by Riker's Laboratories, Inc., Los Angeles, Calif. The authors thank George L. Maisson for his kind cooperation.

it may be assumed that either the radiocalcium was removed from a homogeneous pool or that its deposition and removal occurred in the same area. Induced excess excretion of Ca^{45} and of other metals was also found after the administration of Ca-Na-EDTA . These experiments will be reported in detail elsewhere (19, 20).

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Agglutinin Linkage and Antibody Globulins

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Linkage of anti-A and anti-B isoagglutinins in some O sera was demonstrated by Landsteiner and Witt (1). Similar linkage can be demonstrated in some cases between "nonspecific cold agglutinins" which occur normally in most sera and cold agglutinins acting specifically at higher temperatures. A typical example out of nine such sera is given below.

An A_2B serum containing the "extra" agglutinin α_1 (anti- A_1) was repeatedly absorbed in the cold with O cells. Considerable loss of the anti- A_1 resulted.

Titer before absorption:	256
Titer after absorption:	16

Thirty sera containing isoagglutinins were similarly absorbed in the cold with O cells. There was no loss of isoagglutinin titer in any of these sera.

Linkage may therefore exist between isoagglutinins and isoagglutinins, and between cold agglutinins and cold agglutinins, but not between isoagglutinins and cold agglutinins. It appears that linkage can only take

place between antibodies in the same globulin fraction.

This would be supported by the biochemical findings of Cohn (2) who showed that isoagglutinins do not belong to the γ -globulin fraction, to which cold agglutinins are believed to belong (3). The absorption experiments of Crawford and Mollison (4) also indicate that isoagglutinins and cold agglutinins belong to different globulin fractions. By absorption of anti-globulin sera with sensitized red cells from cases of hemolytic anemia, or with cells that have been exposed to incomplete anti-Rh, or to normal cold antibodies, they were able to prepare sera which would no longer agglutinate the type of cells used for absorption but could agglutinate one or more of the other types.

The work of Crawford and Mollison also suggests that the auto-antibodies of hemolytic anemias differ from the normal cold auto-antibodies. This would be in keeping with the different mode of origin of the two types, which are thought to arise from auto-immunization and heterogenetic bacterial stimuli, respectively. It would be difficult to confirm this by agglutinin-linkage studies, because the various red cells used for absorption would act in a similar manner upon both these types of antibodies.

Wiener (5) has emphasized that there is a slender line of demarcation between isoagglutinins and cold agglutinins. This is undoubtedly so, but there does seem to be a difference in their behavior when absorbed in the cold with O cells.

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Motor Nerve Filament Block Produced by Botulinum Toxin¹

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Burgen, Dickens, and Zatman (1) have shown that during the neuromuscular paralysis produced by botulinum toxin (type A) excitation of a motor nerve releases no acetylcholine (ACh) from its muscular terminals. This finding could be explained by assuming either that the toxin blocks motor nerve terminals just proximal to the site of ACh-release, or that it interferes with the process of release itself. Experiments were carried out to decide between the two alternatives, using the cat's gracilis muscle *in situ* (2) and the guinea pig's excised serratus muscle

¹ This work will be reported in full at a later date. The project was supported by a grant from the Defence Research Board of Canada.

(3), mounted in a bath of oxygenated Ringer-Loeke solution.

Neuromuscular block was produced by intravenous injection of 10^5 mouse LD₅₀, or by addition of toxin to the muscle bath (10^3 to 5×10^4 mouse LD₅₀/ml bath fluid). Action potentials of either groups of muscle fibers or of single fibers were recorded from the surfaces of the muscles at an end plate region. The end plate region was located by applying decamethonium or curare and finding sites from which end plate potentials could be recorded. Toxin was administered after neuromuscular transmission had been restored.

Conduction in nerve trunks, or in muscle fibers that were stimulated directly, was not affected by the toxin. On the other hand, it could be shown that the constituent muscle fibers of a motor unit become inexcitable to stimulation through the nerve trunk one at a time, or in very small groups. It was found that the block produced by botulinum toxin in its early stages can be overcome by the second of two motor nerve volleys, separated by at least 0.8 msec. If botulinum toxin paralyzes by reducing the ACh-output at nerve endings, rather than by blocking conduction in motor terminals, then the second, successful volley should be preceded by an end plate potential in response to the first, unsuccessful volley. However, no end plate potentials could be recorded in response to the first volley when it failed to excite.

The above electrophysiological evidence suggested that action of the toxin is on the nerve filaments rather than on the mechanism of ACh-release. If that is true, stimulation of the nerve terminals resulting from the current that passes through the muscle during direct tetanization of the muscle should release the normal amount of ACh from a preparation that was paralyzed to nerve trunk stimulation by botulinum toxin. Measurements were therefore made of the ACh released by the guinea pig's excised diaphragm (a) during tetanization of the phrenic nerves, and (b) during direct stimulation of the muscle. Direct stimulation of the muscle released the same amount of ACh as indirect stimulation, of the same frequency and duration. Blocking doses of toxin prevented the release of ACh by nerve stimulation, but failed to alter the release by direct stimulation.

It is concluded that botulinum toxin (type A) produces neuromuscular paralysis by interfering with conduction in the terminal twigs of motor nerves, close to, or at, the points of final branching, but proximal to the site of ACh-release.

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Comments and Communications

Altman's Theory of Economic Cycles

It is intriguing to find in a leading scientific journal a paper that treats the mysteries of economic cycles with such assurance and finality as to arrive at a "mathematically necessary result." The "mathematically necessary result" of George T. Altman's "Cycles in Economics and Nature," to be cited as "CiEaN" (*SCIENCE*, 115, 51 [1952]), means that the only way for the United States to escape repeated disastrous depressions is to change to socialism. Is such a conclusion justified?

Altman's theory, as elucidated with the aid of his book *Invisible Barrier* to be cited as "IB" (Los Angeles: DeVorss & Co. [1949]), apparently runs as follows: In a particular country at a particular time, because of limitations imposed by manpower, natural resources, and the level of technological development, there is only a certain maximum amount of capital (v in CiEaN; C_0 in IB) that can be utilized efficiently. Capitalists, driven by the profit motive, periodically increase total invested capital (y in CiEaN; C in IB) till it becomes greater than v . This investment of "too much capital" causes the profit rate to fall. When the profit rate falls, capitalists sharply

reduce investment, causing economic collapse. This reduction in rate of investment eventually causes y to become less than v . Consequently, profits rise, capitalists increase rate of investment, and another boom is on its way. These effects depend upon real, physical limitations on the use of capital and are not dependent upon speculative or inflationary value changes. The only satisfactory escape from recurrent cycles of boom-and-bust is to replace the profit motive by government control.

So runs the theory. In addition, Altman discusses in CiEaN a certain type of ecological system. His presentation of a single mathematical model supposed to fit both economic and ecological cycles may make it appear that the economic theory is based upon fundamental laws of nature applying to all living systems. I believe the appearance is illusory and that the ecological phenomena have no more to do with economic cycles than Newton's third law of motion has to do with rates of animal reproduction (see CiEaN, par. 9). For any of the numerous extant cycle theories, a mathematical model can be found, and it would be surprising if even one of these models should be without a counterpart in nature.

Let us consider four questions concerning Altman's theory.

1) *Do increases in total investment beyond "the capacity of the economy to utilize capital" cause decreases in profit rate?* Profit rate, as Altman employs it, is total profits divided by y , but y is taken not for the current year but for c (in $CiEaN$; t in IB) years earlier (IB , pp. 87, 145). Values of y (C) are tabulated on page 204 of IB for 1918 through 1947, and total corporate profits are tabulated by quarters for 1920 through 1938 in Barger's *Outlay and Income in the United States 1921-1938* (New York: National Bureau of Economic Research, 297 ff. [1942]). Since Altman does not specify an exact value for c , we cannot calculate exact profit rates. However, the fractional rate of change in total profits is so much greater than the fractional rate of change in y , that profit rate must be roughly proportional to total profits—whatever reasonable value we assume for c . Now, if investment ever was too great, it was surely so in the United States during the twenties, yet total corporate profits increased with extreme rapidity from 1927 on, reached a maximum in the third quarter of 1929, and were almost as high in the fourth quarter. The turning point marking the beginning of the Great Depression came in the second quarter of 1929, according to the most authoritative study yet made (Burns, A. F., and Mitchell, W. C. *Measuring Business Cycles*. New York: National Bureau of Economic Research, 78 [1946]). Thus it appears that a long period of "too much capital" resulted in an extraordinary rise in profit rate—although profit rates eventually fell after the depression was well under way.

2) *Is a fall in profit rate the usual cause of a decrease in investment?* According to G. H. Moore's study of "Statistical Indicators of Cyclical Revivals and Recessions" (National Bureau of Economic Research Occasional Paper 31, 64 [1950]), total corporate profits customarily pass through their peaks at about the same time as *general business activity*, whereas "new orders, durable goods industries," "residential building contracts," and "commercial and industrial building contracts" go through their peaks several months earlier. Thus it appears that decreases in the rate of investment usually *precede* decreases in profit rate.

3) *Does Altman's mathematical model fit observed economic behavior?* Neither in $CiEaN$ nor in IB does Altman attempt to show that a fit can be obtained. Furthermore, there is good reason to think that a fit cannot be obtained. His equations ($CiEaN$, par. 8; IB , p. 160) are of sinusoidal form, and Burns and Mitchell (*op. cit.*, p. 157), after detailed study of 1277 economic series, concluded: "Chart 16 suggests, and our later monographs will demonstrate in detail, that there is little justification for the common notion that . . . a sine curve is a satisfactory 'approximation' or 'model' of the specific cycles found in experience."

4) *Does Altman's general theory quantitatively fit observed economic behavior?* According to Fig. 9 of

IB , total invested capital (y or C) in the United States exceeded "the capacity of the economy to utilize capital" (y or C_s) from about 1922 to 1942. During this period there were at least three complete business cycles (Burns and Mitchell, *op. cit.*, p. 78).

It seems to me that Altman has not proved his version of Marx' theory of economic cycles, and that to try to reduce economic cycles to a simple question of "too much capital" or "too little capital" is like trying to explain all of chemistry in terms of the four elements of the alchemists. What does actually cause economic cycles? Under private enterprise, levels of economic activity are obviously determined largely by decisions of entrepreneurs, and these decisions are based upon *expectations* of profits. Actual current profit levels are only one of many determinants of expectations, and they do not appear to be a crucially important one. Expectations are determined by all sorts of things, ranging from mathematically sophisticated extrapolations of past behavior, to communications from the spirit world relayed through the comic strip "Bringing Up Father" (see "From the Spirit's Mouth," *Newsweek*, pp. 60 ff. [Sept. 27, 1948]). And then the situation is further complicated by that common occupational disease of entrepreneurs, which might be named the Thompson syndrome:

Up vistaed hopes I sped;
And shot, precipitated,
Adown Titanic glooms of chasm'd fears—

In view of the labyrinthine ways of capitalist mentality, it seems improbable that any mathematically simple, single-cause theory of economic cycles can be successful.

With the publication of "Cycles in Economics and Nature" (using the pretext of being primarily interested in cycles in nature), *SCIENCE* has invaded the social sciences. I think this is all to the good, for such questions as whether socialism or capitalism is economically superior are of greater importance to most readers than are many of the questions considered in *SCIENCE*. Since economics is still at a developmental stage from which the natural sciences have largely emerged, it would be interesting to see in *SCIENCE* occasional examples of what contributions the natural sciences can make to economics. Perhaps such new tools as the operational definition can clarify old problems. Perhaps the time approaches for a new Boyle to produce a *Sceptical Economist*.

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MR. PRICE's summary of my theory is substantially correct, but the word "periodically" comes a little early in his summary. The periodicity results from the excess of the rate of investment; it is not the direct, initial product of the profit motive. The excess of the rate of investment, in turn, results because there is no effective control of that rate except the profit or loss

realized, and that realization is not immediate but comes only after a lapse of time.

Mr. Price's only serious attack upon my theory is that it is not supported by statistical fact. His argument, however, is founded on an assumption shown by the original sources as completely false. I refer to his assumption that "the fractional rate of change in total profits is so much greater than the fractional rate of change in y , that profit rate must be roughly proportional to total profits."

TABLE 1*

	1928	1929	1930
Industries covered by Barger	5,066.0	5,952.0	1,663.6
Industries omitted by Barger	1,976.0	1,595.0	823.6
Total	7,042.0	1,547.0	840.0

* In millions of dollars. Source: *Statistical Abstract of the U. S.*, Table 189 (1931); Table 179 (1932); Table 181 (1933).

In the first place, the figures upon which Mr. Price relies for total profits, those of Harold Barger,¹ represent only corporate profits, whereas the figures upon which he relies for y are those of the invested capital of the entire economy.² In the second place, even the figures for corporate profits do not represent the profits of all corporations, but only those of certain classes of corporations. Trade, finance, and agricultural corporations are wholly omitted.³ The seriousness of that error may be quickly seen in the data for "statutory net income" less taxes payable thereon (Table 1), "statutory net income" being net profits after excluding dividends received from domestic corporations and tax-exempt interest.

There is no objection, of course to the general mode of Mr. Price's inquiry. If statistics are available, my theory should be able to stand up to them. For this purpose I have developed Table 2. Prior year loss is not deducted; the dividends and interest excluded are as shown.

TABLE 2*

	1928	1929	1930
Industries covered by Barger			
Dividends	1,160.5	1,548.2	1,419.8
Interest	137.3	137.6	123.0
Industries omitted by Barger			
Dividends	756.5	1,044.8	1,151.2
Interest	455.7	398.4	413.0

* In millions of dollars. Source: Same as in Table 1.

The amounts shown for each first quarter in the first column of Table 2 were derived, for 1927 and subsequent years, from the asset and liability data tabulated from income tax returns and published in "Statistics of Income." Asset and liability data for prior

¹ *Outlay and Income in the United States 1921-1938*, New York: National Bureau of Economic Research, 297 ff., (1942).

² *Invisible Barrier*, p. 204.

³ Barger. *Op. cit.*, p. 300, note c.

periods also appear in "Statistics of Income," but they are figures derived from capital stock tax returns, and in respect to total invested capital those returns are not adequately comparable with income tax returns, particularly because of the consolidated returns allowed for income taxes. Because of this fact, the figures for the first quarters of earlier years were developed by deducting, year by year, the annual amounts of reinvested earnings and stock issues for new capital.⁴ The amounts for the second, third, and fourth quarters of each year were interpolated by means of percentages composed to the extent of $\frac{5}{8}$ from the quarterly distribution of new capital issues⁵ and $\frac{3}{8}$ from Barger's quarterly distribution of earnings, the respective weights of $\frac{5}{8}$ and $\frac{3}{8}$ giving effect very roughly to the relative weights of new capital and reinvested earnings in the growth of corporate capital.

These figures contain, it is true, two substantial flaws. The stock issues for new capital used in deriving the pre-1927 figures represent only public issues. That flaw, however, greatly reduces the increase in the figures from year to year and is therefore an error in Mr. Price's favor. The other flaw is that the figures taken from "Statistics of Income" for the years 1927-29, inclusive, include stock owned in other domestic corporations, which is a duplication cognate with the inclusion in corporate income of dividends received from other domestic corporations. Because of that error, for correction of which no reliable data are available, the first column of figures in Table 3 is given for comparative and corroborative purposes only.

The second column is much more accurate. It contains only the physical assets—inventories, real estate, plant, and equipment. In respect to those assets the income tax returns and capital stock tax returns are fairly comparable, so that an actual compilation year by year is available. The intermediate quarterly figures are interpolated in the same manner as for the first column.

The third column is the statutory net income less taxes. The source of the figures, "Statistics of Income," shows also that nonexempt interest received and interest paid are roughly equal. The figures in the third column may therefore be regarded as true net operating income; hence they can be properly evaluated against tangible investment. The annual totals as taken from "Statistics of Income" are distributed among the quarters on the basis of Barger's data on quarterly earnings.

The figures in the fourth and last column are obviously obtained by dividing those in the third column by those in the second for the same quarter. One could

⁴ The figures on reinvested earnings are given in *Invisible Barrier*, p. 83, and the sources are therein noted. Figures for new capital issues are also given there, and the stock portions thereof were determined by reference to the original sources there cited. See also *Statistical Abstract of the United States*, 313 (1930).

⁵ Source: *Review of Economic Statistics*, Vol. 14, 190.

TABLE 3
QUARTERLY PROFIT RATE OF UNITED STATES CORPORATIONS
(Amounts in Billions of Dollars)

Year and quarter	Net worth at beginning of quarter	Tangible assets at beginning of quarter	Statutory net income less taxes	Quarterly profit rate (%)
1922—1	101.0	84.3	.53	.63
2	101.5	85.5	.93	1.09
3	102.4	87.4	1.01	1.16
4	103.1	88.8	1.51	1.70
1923—1	103.8	90.3	1.54	1.70
2	105.0	93.2	1.64	1.76
3	105.9	95.5	1.20	1.26
4	106.5	97.0	.99	1.02
1924—1	107.4	99.2	1.39	1.40
2	108.2	101.4	.94	.93
3	109.0	103.6	.90	.87
4	109.6	105.2	1.25	1.19
1925—1	110.4	107.5	1.48	1.38
2	111.7	109.0	1.55	1.42
3	112.9	110.4	1.68	1.52
4	114.0	111.7	1.74	1.56
1926—1	115.3	113.3	1.51	1.33
2	116.4	114.7	1.57	1.37
3	117.5	116.0	1.63	1.41
4	118.4	117.2	1.57	1.34
1927—1	119.3	118.4	1.45	1.22
2	122.8	120.4	1.29	1.07
3	126.1	122.3	1.35	1.10
4	128.9	123.9	1.29	1.04
1928—1	132.4	125.9	1.48	1.18
2	134.6	126.9	1.62	1.28
3	137.4	128.2	1.84	1.42
4	139.5	129.2	2.10	1.63
1929—1	142.9	130.7	1.79	1.37
2	147.6	132.8	1.95	1.46
3	152.5	134.9	2.08	1.54
4	157.0	136.9	1.73	1.26
1930—1	160.3	138.3	.36	.26

divide the figures in the third column by those in the second column for an earlier quarter—say, a year or more back—in order to allow for a development period in respect to new capital, and thus relate earnings to the capital from which they were expected. As a quick computation will show, however, the relative profit-rate position of the various quarters would be almost precisely the same. The obvious reason is the fact that during the particular years involved the rate of growth of total capital invested was fairly constant.

The profit-rate figures shown tell a very clear story. First, during the eight years 1922–29, inclusive, the earnings rate was quite stable—indeed, remarkably stable for such a long period and in an unsupported and uncontrolled economy. Second, during five quarters, three of which were in succession, the earnings rate was higher than during any quarter in the historic boom year of 1929. Third, the rise in profit rate from 1927 reached its peak in the last quarter of 1928. Fourth, the profit-rate peaks were followed, as well as preceded, by a high rate of investment; and the new capital issues of 1927–29 reached their peak in the second quarter of 1929 and were still high in

the third quarter of that year. Decreases in the rate of investment, it can only be concluded, do not precede decreases in the profit rate. When decreases in the rate of investment do develop, it is only after the profit rate has fallen, or a rise in the profit rate has failed to keep going or to hold.

Thus my theory is consistent with observed economic behavior. Increases in the rate of investment contribute to increases in the profit rate—up to a certain limit. After that limit is reached a high investment rate will continue in expectation of the same high, or still higher, profits. But it is doomed to disappointment. An excess of investment is created, and a compensating decline must follow.

TABLE 4
QUARTERLY PROFIT RATE OF UNITED STATES CORPORATIONS
(Amounts in Billions of Dollars Adjusted to a 1929 Price Basis)

Year and quarter	Tangible assets at beginning of quarter	Statutory net income less taxes	Quarterly profit rate (%)
1922—1	93.3	.546	.58
2	94.5	.930	.98
3	96.4	.97	1.00
4	97.8	1.43	1.46
1923—1	99.4	1.42	1.43
2	102.0	1.53	1.50
3	104.1	1.16	1.11
4	105.5	.96	.91
1924—1	107.5	1.33	1.24
2	109.6	.93	.85
3	111.7	.89	.80
4	113.4	1.195	1.05
1925—1	115.6	1.359	1.18
2	117.1	1.445	1.23
3	118.5	1.54	1.30
4	119.8	1.596	1.33
1926—1	121.4	1.41	1.16
2	122.8	1.49	1.22
3	124.1	1.56	1.26
4	125.2	1.52	1.21
1927—1	126.4	1.44	1.14
2	128.5	1.31	1.02
3	130.4	1.35	1.03
4	132.0	1.27	.96
1928—1	134.1	1.47	1.10
2	135.1	1.58	1.17
3	136.4	1.77	1.30
4	137.4	2.06	1.50
1929—1	139.0	1.78	1.28
2	141.1	1.95	1.38
3	143.2	2.06	1.44
4	145.1	1.75	1.20

As to economic conditions subsequent to the Great Depression, very little information can be derived from them. Since 1933 the economy has been an increasingly supported economy. From such an economy few principles can be drawn that are valid for an economy which must stand upon its own feet. The question is, what will happen when the supports are gone?

Finally, Mr. Price objects to my suggestion that the economic cycle can be described sinusoidally. In the

first place, as I pointed out in *Invisible Barrier* (p. 158), there are secondary factors, such as the variations in crop conditions and technological advance, which must be added to the primary curve of the investment and profit cycle. In the second place, in the sentence quoted by Mr. Price from Burns and Mitchell, those authors must, especially in view of their own chart, have meant by the sine curve the simple $y = a \sin x$, whereas in my paper in *SCIENCE* it is obvious, from my equations and the sentence following them, that I was not using the term sinusoidal in the same simple sense, but rather in the sense of a curve oscillating in the manner of a sine curve.

I disregard Mr. Price's reference to Marx. There is no kinship whatever between my theory and the surplus-value theory of Marx. Not that I would yield if there were. It is the province and duty of science to search for truth, and truth cannot be hemmed in by label or dogma. When that time comes science is doomed, and in whatever land.

Addendum: I have recomputed, in terms of a standard dollar, the schedule of figures in Table 3. For this purpose I used the 1929 dollar, but I am not contending that the standard dollar is a necessary refinement for this purpose. I am only presenting the figures (Table 4) for anyone who might so believe, in order to show that the results are substantially the same on that basis.

In arriving at these figures, the net income for each quarter was adjusted to the 1929 dollar on the basis of the wholesale price index. The increase in corporate investment for each quarter was adjusted to the 1929 dollar on the basis of the index used by Kuznets for gross capital formation in *Commodity Flow and Capital Formation* (Vol. 1, Table VIII-2).

The figure for corporate investment at the beginning of 1922, exclusive of inventories, was adjusted to the 1929 dollar on the basis of a composite index, for years prior to 1922, made up of average hourly earnings in the building trades with a weight of $\frac{1}{4}$; building materials prices with a weight of $\frac{1}{4}$; and the prices of metals and metal products with a weight of $\frac{1}{2}$. The amount distributed to each year preceding 1922 is a percentage of the total increase in tangible fixed assets of corporations for the years 1922-29, inclusive, indicated by data for new manufacturing capital expenditures for plant and equipment. Such data go back only to 1915. The amount not accounted for in the years 1915-21 was treated as derived from the period 1905-14.

The inventory segment of total corporate investment as of the beginning of 1922 was, at current prices, already substantially on a 1929 price basis. The method of adjusting for each quarter only the increase in total tangible investment for that quarter is also substantially accurate in respect to the inventory segment because of the stability of the price level for the period 1922-29. No greater accuracy could be achieved because it would be impossible to state with the necessary precision the years from which each in-

ventory total was derived, the portion priced at cost, the portion priced at market, etc.

It is clear that the conclusions derived from the figures prepared on a current-price basis still follow when the figures are adjusted to a standard dollar.

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Shipment of Animal Disease Organisms and Vectors

THE accompanying statement is self-explanatory. We have found, in cases of illegal movement of these materials, the scientific personnel involved were not acquainted with the requirements of law.

Since we are trying to reach scientific personnel with this information, we hope you will find space to include it in your journal.

HUGH C. MCPHEE

Bureau of Animal Industry, USDA
Washington, D. C.

NOTICE TO LABORATORIES, RESEARCH INSTITUTIONS, AND INDIVIDUALS STUDYING ANIMAL DISEASES

Permit Required to Import or Transport Interstate Restricted Animal Disease Organisms and Vectors

In recent months several instances of illegal movement of animal disease organisms and vectors in interstate commerce have come to the attention of the U. S. Department of Agriculture. Conditions under which restricted organisms and vectors can be moved under permit are explained in the Department's Bureau of Animal Industry Order 381, Part 122, entitled "Rules and Regulations Relating to Viruses, Serums, Toxins, and Analogous Products, and to Certain Organisms and Vectors."

Because of the inherent danger of such movements and the increasing need for taking every precaution against the spread of infectious animal diseases, all laboratories, research institutions, and others dealing with animal disease organisms and vectors are requested to comply with this order. Movements are allowed under permit only when such shipments serve the public interest and after ample safeguards are provided to protect against the further dissemination of such agents.

The Act of Congress approved February 2, 1903 (32 Stat. 792; 21 U.S.C. 111) confers upon the Secretary of Agriculture authority to make such regulations and take such measures as he may deem proper to prevent the introduction or dissemination of the contagion of any contagious, infectious, or communicable disease of animals from a foreign country into the United States or from one State or Territory of the United States or the District of Columbia to another . . . whenever in his judgment such action is advisable in order to guard against the introduction or spread of such contagion.

Under that authority, Part 122 of BAI Order 381, "Rules and Regulations Relating to Viruses, Serums, Toxins, and Analogous Products, and to Certain Organisms and Vectors," provides that no organisms or vectors shall be imported into the United States or transported from one State or Territory or the District of Columbia to another State or Territory without a permit issued by the Secretary and in compliance with the terms thereof.

Section 122.2 provides that the Secretary may issue at his discretion a permit when proper safeguards have been set up to protect the public. Application for such a permit shall be made in advance of shipment, and each permit shall specify the name and address of the consignee, the true name and character of each of the organisms or vectors involved, and the use to which each will be put.

All persons engaged in research involving the use of organisms or vectors as defined above should become familiar with the contents of this notice. Further information and applications for permits may be obtained by writing to the Chief, Bureau of Animal Industry, U. S. Department of Agriculture, Washington 25, D. C.

Parameters for the Description of Transition States

OF ALL the properties of the transition state, the free energy is the most valuable. From it may be calculated reaction rates and, consequently, the product composition of competitive reactions. In principle the free energy of the transition state may be calculated in two ways: (a) by statistical mechanics, and (b) by equations relating it to other measurable free energies. The former approach demands data as yet unavailable, and so it is the latter that is the more useful at present. The relationships with known free energies are rational but semiempirical.

Let F_r be the free energy of the reagents, F_p that of the products, and $F_‡$ that of the transition state. Let ΔF_r , ΔF_p , and $\Delta F_‡$ be the decrease in free energy (stabilization) of the reagents, products, and transition state for a change in a given independent variable, such as solvent or structure. A change from benzene to chlorobenzene as solvent or the introduction of a new substituent anywhere but directly at the site of reaction will serve as typical variations.

One rational first approximation is that

$$\Delta F_‡ = \alpha \Delta F_p + (1 - \alpha) \Delta F_r \quad (1)$$

$$0 \leq \alpha \leq 1.$$

This is chosen for the following reasons. We can expect the transition state to be intermediate between the reagent and product with respect to its free energy's sensitivity to changes in the independent variable, just as we expect it to be intermediate with respect to geometry and topology. If we assume that the transition state is intermediate in all its properties, including free energy changes except the absolute magnitude of the free energy itself, it is appropriate to use a linear combination of ΔF_r and ΔF_p as an approximation to $\Delta F_‡$. We can also say that, if the transition state is intermediate, it will resemble the product less when it resembles the reagent more. This is expressed by Eq. (1) in which the parameter α measures the resemblance to the product and has 0 and 1 as limits, whereas $(1 - \alpha)$ measures the resemblance to the reagent. We approximate the transition state by regarding it as a hybrid between the reagent and product states.

Since the quantity $\Delta F_‡$ is not immediately accessible experimentally, it is desirable to rearrange Eq. (1).

Let the superscripts 1 and 2 refer to two values of the independent variable (structure or solvent). Then

$$\Delta F_‡^1 = F_‡^1 - F_‡^0, \Delta F_p = F_p^1 - F_p^0, \Delta F_r = F_r^1 - F_r^0.$$

Eq. (1) then becomes

$$F_‡^1 - F_‡^0 = \alpha F_p^1 - \alpha F_p^0 + F_r^1 - F_r^0 - \alpha F_r^1 + \alpha F_r^0.$$

On rearrangement of terms, and introduction of the conventional symbols

$$\Delta F_1 \equiv F_‡^1 - F_r^1 \text{ and } \Delta F_2 \equiv F_p^1 - F_r^1$$

we have:

$$\Delta F_1 - \Delta F_2 = \alpha (\Delta F_1 - \Delta F_2).$$

If we now introduce an integration constant,

$$\Delta F = \alpha \Delta F + C. \quad (2)$$

Eq. (2) deals with quantities $\Delta F_‡$ and ΔF that are derivable from rate and equilibrium constants. It is equivalent to $\ln k = \alpha \ln K + C'$.

Whenever a plot of the logarithm of the rate constant of a reaction against the equilibrium constant for the same reaction gives a straight line, assumption (1) is justified. Furthermore, the slope of such a line is identifiable as a parameter that measures the degree of resemblance of the transition state to the products, as compared to its resemblance to the reagents.

Fairly precise relationships of the form (2) have been noted in a number of instances. For example, in the dissociation of hexaphenyl ethane, such a relationship obtains between the rates and equilibrium constants for the dissociation in a series of solvents (1). The value of α in this case is only about 0.2, indicating that the transition state resembles the ethane four times as much as it resembles the radical. The resemblance is probably at least partly geometric, the ethane and transition state both being sterically unable to interact strongly with the solvent. If so, it is likely that in the transition state the incipient radicals have not flattened out enough to acquire much resonance energy.

Better examples of relationship (1) are provided by Brønsted catalyses. Hammett has shown (2) for one case of the Brønsted relationship between the rate constant and the ionization constant of the catalyzing acid that there is derivable a linear relationship between the log of the rate constant and the log of the equilibrium constant of the same reaction (not just the acid ionization). The same appears to be true for most Brønsted relationships. From the slope of the Brønsted relationship it is therefore possible to calculate α . The variable in these relationships is the structure of the catalyzing acid.

There are several possible applications for α once it has been obtained. The value observed may be incompatible with one of several otherwise possible reaction mechanisms, thereby eliminating that mechanism. For example, consider a reaction thought to involve proton transfer $A^- + HB \rightleftharpoons AH + B^-$, a fairly usual rate-determining step. A rough estimate of α can be obtained from the following consideration: A transition state differs from ordinary molecules in that

with respect to one of its coordinates (the reaction coordinate) it has a *maximum* rather than a *minimum* free energy. If the reaction coordinate measures proton transfer, we can therefore say that in the transition state the weaker base will be more nearly neutralized than the stronger base; that is, if, in the reaction above, A^- is a weak base like a carboxylate ion, and B^- is a strong base like a carbanion, the value of α will be high (0.6 to 1.0), since the transition state must resemble the product in such a case. If the observed value of α is outside this range, the mechanism should be discarded. A proper value of α is one more criterion for an acceptable mechanism. In the base-catalyzed mutarotation of glucose we may discard the hypothesis that the nonconcerted formation of the glucose negative ion is rate-determining. The value of α is so low that the transition state would have to resemble un-ionized glucose. But this will not do, since the glucose ion must be a stronger base than carboxylate ions. The necessity for dependence of α on base strength means that, for extremely large changes in ionization constant, the Brønsted relationship will depart from linearity. This sort of restriction is typical of most linear free energy relationships.

There are several other possible applications of a not yet tested because of insufficient data. It should

be possible to apply an α chosen for best fit to the relationship under changes in structure to the relationship under changes in solvent, and vice versa. Structural data should help in predicting the effect of solvent changes, and solvent data should help in predicting the effect of structural changes. This is not surprising, because the effect of solvent on reactions is very much like the effect of a substituent and can sometimes be explained by electronic interpretations similar to those applied to substituents. A still more conjectural application is to the absolute prediction of reaction rates largely from nonrate data. We may shortly expect a solution to the problem of predicting the free energy of stable molecules in mixed solvents. It should then be possible to predict the free energy of the transition state by a linear combination of the predictions made for the reagents and for the products.

JOHN E. LEFFLER

Department of Chemistry
Florida State University

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Book Reviews

Seismic Prospecting for Oil. Charles Hewitt Dix. New York: Harper, 1952. 414 pp. Illus. \$7.50.

For some 30 years, applied seismology has occupied a position of supreme importance in the search for oil deposits. A textbook specifically devoted to present-day seismic prospecting and, more particularly, to the techniques of converting the field data into terms of geological significance on maps, is therefore to be welcomed. This book, in fact, treats all phases of the interpretation procedures, from the reading of "raw" seismograms to the compilation of the finished maps and reports. It does not deal with instrumentation.

The book consists of five parts, containing some 15 chapters. Each chapter is preceded by a paragraph or so introducing its material and stating for whom it is specifically intended. Consequently, the field man on a seismic crew and the exploration geologist will find the book good reading and of considerable value, even though it is strictly functional—that is to say, it is primarily a manual of procedures, rather than a continuous development of its subject matter.

The author has been engaged in seismic prospecting for oil for almost 20 years. This practical experience, coupled with his scholarly background, serves to make him an outstanding authority. Aware of these facts, the reviewer is disappointed to find the looseness of language and presentation which pervades the book.

Presumably in the interest of economy of printing, practically all the mathematical developments are arranged as parts of the figures, with results that are most unfortunate insofar as clarity of expression is concerned. A more conscientious editing of the text, and a more orthodox arrangement of the mathematical arguments would have enhanced the value of the book for both the professional seismologist and the student.

For the student, in fact, the functional aspect of the book is at times disturbing. The economics of seismic operations, the personnel components of a crew—such matters are all discussed. Elasticity, wave propagation, and seismic recording are sketchily, although perhaps adequately, presented. There is, however, no historical background of seismology, applied or otherwise, which one might expect to be treated at least briefly in a book of this type. The refraction technique of seismology is only lightly touched upon—a fact presumably in keeping with its present-day low economic importance.

As a textbook, it presents little challenge to the ingenuity or the initiative of the student. It is for that reason that it will find its greatest use as a reference book for men already working as seismologists in the oil industry, and in those many college courses of the "spoon-feeding" type.

M. M. SLOTNICK

Humble Oil & Refining Company, Houston, Texas

Maleic Anhydride Derivatives: Reactions of the Double Bond. Lawrence H. Flett and William Howlett Gardner. New York: Wiley; London: Chapman & Hall, 1952. 269 pp. \$6.50.

This book presents in simplified form some 116 chemical reactions involving maleic anhydride or one of its unsaturated derivatives. These reactions are those characteristic of the olefinic nature of maleic anhydride and represent the kind of reaction which would be of prime interest to the industrial chemist. Each reaction is presented with fair detail, especially in regard to experimental quantities used and scope of the reaction type. Along with this, the authors give pertinent references to the literature.

As one might expect, and as is pointed out by the authors, a presentation of this type suffers from several disadvantages. Primarily, the book is limited in scope and does not discuss the theoretical or mechan-

istic viewpoint of the chemistry involved. Also, no attempt is made to present or discuss the various factors affecting the course of the reactions involved which would increase the value of the book. In addition, the classification system used has certain inherent disadvantages, so that the reader finds, for example, the reactions of organocadmium and organolithium compounds listed under Grignard reagents and the reactions of alcohols listed as those of their metallic salts.

However, the book is a useful addition to the already large number of those dealing with organic reactions. The concise presentation of the data and the general ease by which it may be located are to be especially commended. The book is recommended to those chemists whose principal interest is in the field of synthetic organic chemistry.

OGDEN R. PIERCE

Chemistry Department, Purdue University



Scientific Book Register

The Mathematical Theory of Non-Uniform Gases. An account of the kinetic theory of viscosity, thermal conduction, and diffusion in gases. 2nd ed. Sydney Chapman and T. G. Cowling. New York: Cambridge Univ. Press, 1952. 431 pp. Illus. \$10.50. (Suppl. vol. for owners of the first edition: *Notes Added in 1951*. Pp. 392-431. \$1.00.)

Josiah Willard Gibbs: The History of a Great Mind. Rev. ed. Lynde Phelps Wheeler. New Haven, Conn.: Yale Univ. Press; London: Geoffrey Cumberlege, Oxford Univ. Press, 1952. 270 pp. and plates. \$4.00.

The Chemistry and Physiology of the Nucleus. *Experimental Cell Research*, Suppl. 2, 1952. Proceedings of the symposium held August, 1951 by the Biology Department, Brookhaven National Laboratory. V. T. Bowen, Ed. New York: Academic Press, 1952. 402 pp. Illus. \$7.00.

Advanced Mechanics of Materials. 2nd ed. Fred B. Seely and James O. Smith. New York: Wiley; London: Chapman & Hall, 1952. 680 pp. Illus. \$8.50.

Headaches: Their Nature and Treatment. Stewart Wolf and Harold G. Wolff. Boston: Little, Brown, 1953. 177 pp. \$2.50.

Annual Review of Plant Physiology, 1952, Vol. 3. Daniel I. Arnon, Ed., and Leonard Machlis, Assoc. Ed. Stanford, Calif.: Annual Reviews, 1952. 369 pp. \$6.00.

Dairy Engineering. 2nd ed. Arthur W. Farrall. New York: Wiley; London: Chapman & Hall, 1953. 477 pp. Illus. \$6.00.

Eugenics: Galton and After. Carlos Paton Blacker. Cambridge, Mass.: Harvard Univ. Press, 1952. 349 pp. Illus. \$5.00.

Methoden der Organischen Chemie. (Houben-Weyl). Band VIII: *Sauerstoffverbindungen* III. 4th ed. Eugen Müller, Ed., with collab. of O. Bayer, H. Meerwein, and K. Ziegler. Stuttgart: Georg Thieme, 1952. 775 pp. DM 98.

The Vertebrate Organism, Part I. Howard H. Hillemann. P. O. Box 491, Corvallis, Ore.: Oregon State College Coop. Assoc., 1953. 122 pp. \$3.12 postpaid.

Superconductivity. 2nd ed. D. Shoenberg. New York: Cambridge Univ. Press, 1952. 256 pp. Illus. \$6.00.

The Theory of Electrons and Its Applications to the Phenomena of Light and Radiant Heat. 2nd ed. Repr. H. A. Lorentz. New York: Dover, 1952. 343 pp. Illus. \$3.50; paperbound \$1.70.

I Drank the Zambezi. Arthur Loveridge. New York: Harper, 1953. 296 pp. Illus. \$4.00.

An Introduction to Scientific Research. E. Bright Wilson, Jr. New York-London: McGraw-Hill, 1952. 375 pp. Illus. \$6.00.

The Composition and Assaying of Minerals. John Stewart Remington and Wilfrid Francis. New York: Philosophical Library, 1953. 127 pp. \$5.50.

Annual Review of Nuclear Science, Vol. 2. James G. Beckerley et al., Eds. Stanford, Calif.: Annual Reviews, 1953. (In cooperation with the National Research Council.) 429 pp. Illus. \$6.00.

Non-Aqueous Solvents: Applications as Media for Chemical Reactions. Ludwig F. Audrieth and Jacob Kleinberg. New York: Wiley; London: Chapman & Hall, 1953. 284 pp. Illus. \$6.75.

Vertebrate Zoology: An Introduction to the Comparative Anatomy, Embryology and Evolution of Chordate Animals. 2nd ed. G. R. de Beer. London: Sidgwick and Jackson, 1951; New York: Macmillan, 1953. 435 pp. Illus. \$5.50.

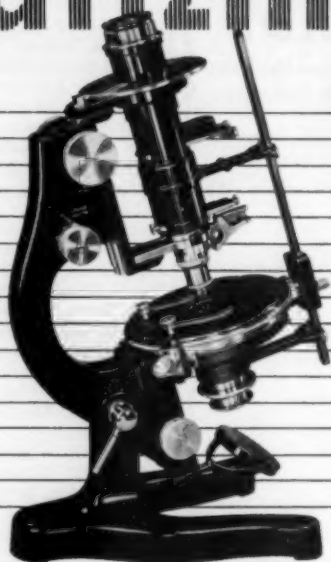
Culture: A Critical Review of Concepts and Definitions. Peabody Museum Papers, Vol. XLVII, No. 1. A. L. Kroeber and Clyde Kluckhohn, with assistance of Wayne Untereiner and appendices by Alfred G. Meyer. Cambridge, Mass.: Peabody Museum of American Archaeology and Ethnology, Harvard University, 1952. 223 pp. \$5.25.

Introductory Mycology. Constantine John Alexopoulos. New York: Wiley; London: Chapman & Hall, 1952. 482 pp. Illus. \$7.00.

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- Apr. 6-10. American Physiological Society (Spring). Chicago.
- Apr. 6-10. Federation of American Societies for Experimental Biology (Annual). Chicago.
- Apr. 8-12. American Heart Association (Annual). Hotel Chelsea, Atlantic City.
- Apr. 9-11. American Association for Cancer Research (Annual). Drake and Knickerbocker Hotels, Chicago.
- Apr. 10-11. Association of Geology Teachers (East-Central Section). University of Cincinnati, Cincinnati.
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- Apr. 16-18. Georgia Junior Academy of Science and Annual Science Fair. Oglethorpe University, Atlanta.
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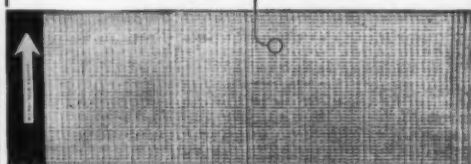
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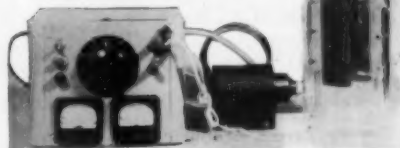
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"Check your air, Sir?"



To keep voices traveling strongly through telephone cables, you have to keep water out. This calls for speed in locating and repairing cable sheath leaks — a hard job where cable networks fork and branch to serve every neighborhood and street.

At Bell Telephone Laboratories, a team of mechanical and electrical engineers devised a way to fill a complex cable system with dry air under continuous pressure. Pressure readings at selected points detect cracks or holes, however small. Repairman can reach the spot before service is impaired.

It's another example of how Bell Laboratories works out ways to keep your telephone service reliable — and to keep down the cost to you.



BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in mechanical engineering



Air compressor and tank at right. Long cylinders on rack dry air before it enters cables.

He's checking the air pressure in a branch cable, one of scores serving a town. The readings along the cable are plotted as a graph to find low-pressure points which indicate a break in the protecting sheath.



Master meters keep watch over the various cable networks which leave a telephone office in all directions to serve a community. Air enters the system at 7 pounds pressure, but may drop to 2 pounds in outermost sections—still enough to keep dampness out.

B. m.